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MACHINE DRAFTING
AND
EMPIRICAL DESIGN

A TEXT-BOOK FOR STUDENTS IN ENGINEERING SCHOOLS,
AND OTHERS WHO ARE BEGINNING THE STUDY OF
DRAWING AS APPLIED TO MACHINE DESIGN

BY
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ADJ. PROFESSOR COLUMBIA UNIVERSITY
AND
JOHN T. WILLIAMS
INSTRUCTOR CORNELL UNIVERSITY

PART I
MACHINE DRAFTING

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PREFACE

PART I

THIS book is prepared after several years' supervision of courses in drafting in engineering schools. Its purpose is to present the subject of drafting to the student in such a manner that its *principles* and *applications* may be thoroughly understood.

For this reason the drawings to be made by the student are given him in the nature of problems requiring a knowledge of the principles of projection.

Instruction in modern drafting-room methods, shop terms, etc., serves to co-ordinate his knowledge of drawing with its practical application, and thus his knowledge is immediately useful.

This course may be taken by beginners in drawing, and to such it has been given with success. A knowledge of the use of the instruments is gained in the making of the drawings.

WALTER RAUTENSTRAUCH.

NEW YORK, October 5, 1907.

MACHINE DRAFTING AND EMPIRICAL DESIGN

PART I

MACHINE DRAFTING

CHAPTER I

GENERAL PRINCIPLES

Drafting is the art by which we express and perfect our constructive ideas. Machine drafting may therefore be defined as the application of this art to the construction of machines. A machine drawing is an assembly of dimensioned views and cross-sections of a machine or a part of a machine, with notes and comments either by words or symbols that are required to correctly manufacture or erect the same.

VIEWS

Let it be required to represent the piece shown in Fig. 1 by means of a drawing as is regularly done in commercial practice. This drawing is to clearly establish all dimensions of the piece so that it may be made in the shops. To proceed, imagine your-

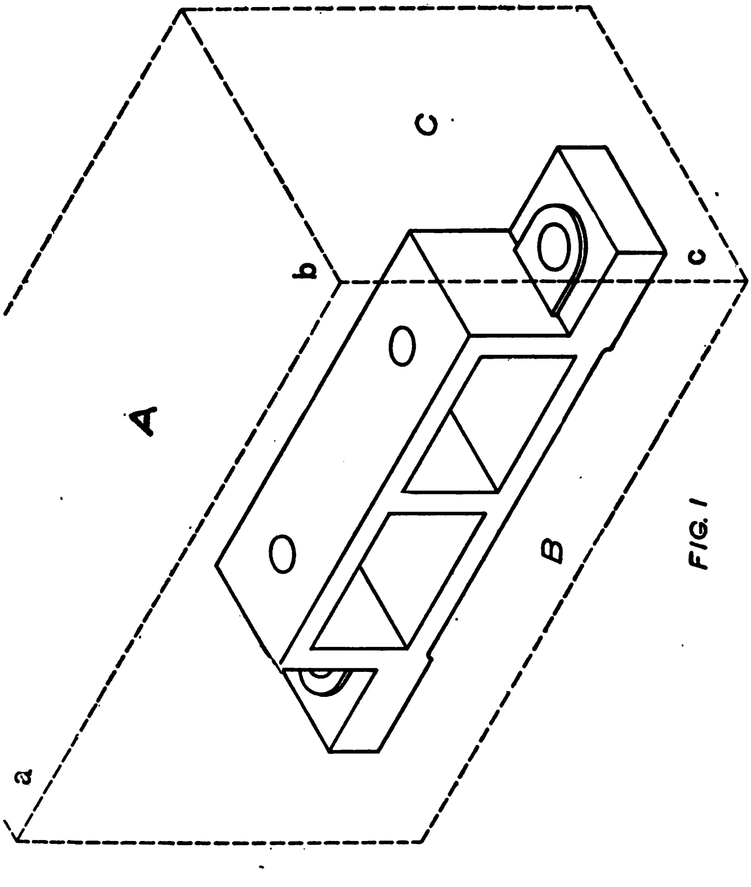


FIG. 1

self placed directly above the object so that a plane *A* could be placed at right angles to your view, Fig. 2. From this position the object would appear as shown on *A*. All visible outlines could be shown by solid lines, and all hidden outlines could be shown by broken lines. Dimensions could also be given on this view so that the sizes of the parts could be established. In like manner a position at right angles to the plane *B* could be taken and the outline of the object as it appeared from this point of view could be represented on plane *B*, Fig. 3. The same remarks are true with respect to plane *C*, Fig. 4, or the other planes enclosing the object. If now the three planes be revolved about the axes *ab* and *bc*, so that the projections of the object on these planes be brought in one plane, these views together with dimensions, notes, etc., would constitute a machine drawing as shown in Fig. 5. It is to be noted in connection with this drawing that a view of any side of the object is next to the side from which the view is taken. This method of representation is what is commonly known as third-angle projection, and is generally used in this country.

This principle must be clearly understood before further study in this subject is continued, and it will therefore be well for the student to select some object and roughly sketch three views of it to see if he understands what has just been explained. Sometimes a drawing of two views of a part will be sufficient to establish its proportions, and sometimes three views are required. In representing a complicated part it is often found that three views are not always clear, whereupon it is customary to show cross-sections of such parts as are particularly difficult to understand. This is done as shown in Fig. 6. It will be noted that at the place of which a cross-sectional view is shown, a light line cuts across the section and its extremities are lettered. This serves to locate the place where the section has been taken, and in consequence the sectional view is noted "Section *A–A*." There may be several sectional views on one drawing. Sometimes it will be

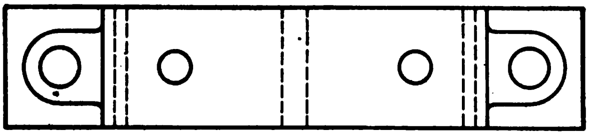


FIG. 2 — TOP VIEW OR PLAN, AS SEEN FROM PLANE A

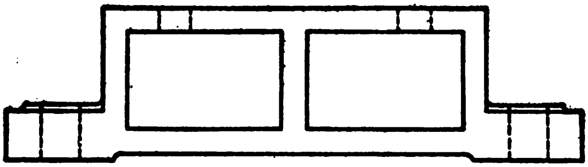


FIG. 3 — SIDE ELEVATION, AS SEEN FROM PLANE B

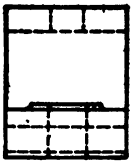


FIG. 4 — END ELEVATION, AS SEEN FROM PLANE C

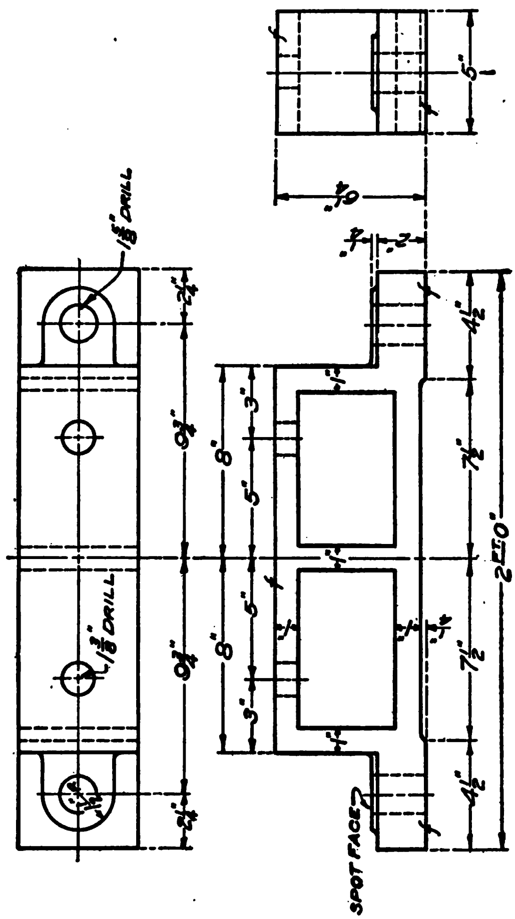
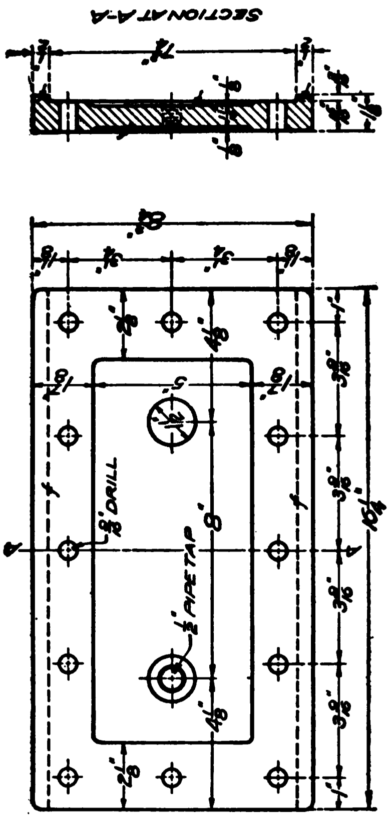

1 5/8" DRILL
1 3/8" DRILL
2 1/4"
9 3/4"
9 3/4"
2 1/4"
8"
8"
3"
5"
5"
3"
1"
4 1/2"
7 1/2"
7 1/2"
4 1/2"
2'-0"
6"
5"
2"
f
SPOT FACE

FIG. 5



COVER-FIG.6

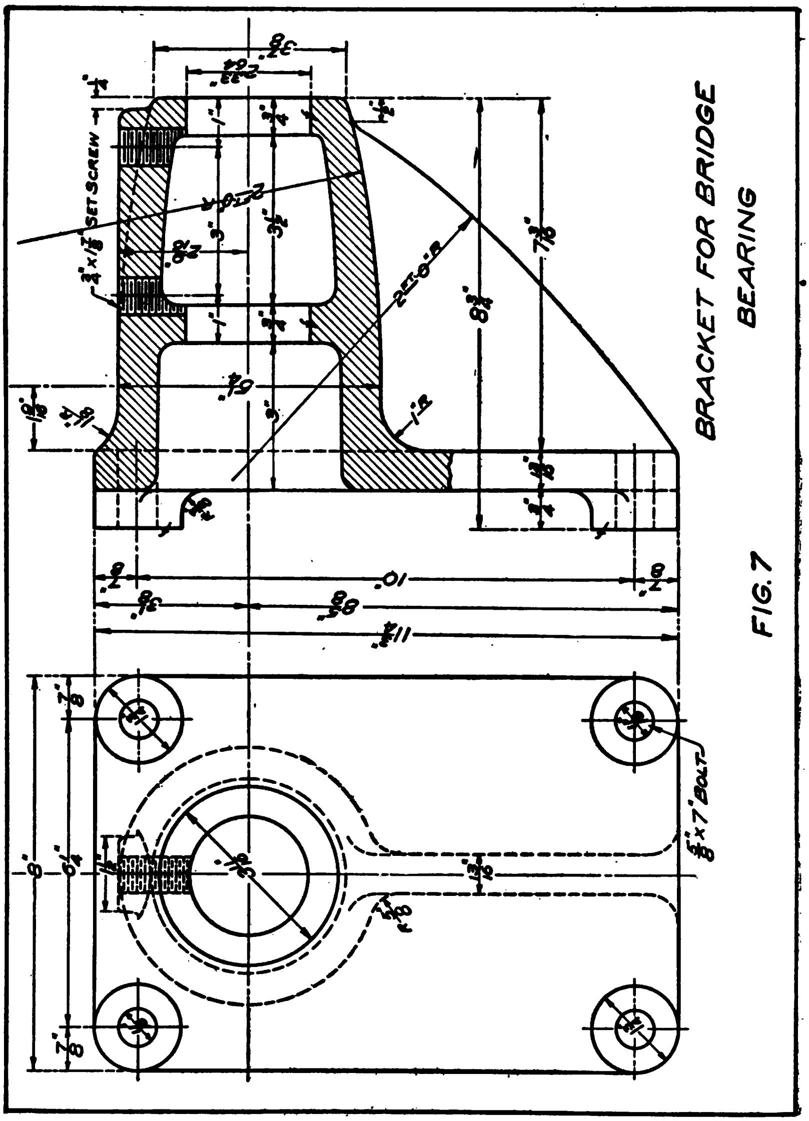
found that one view and a total half-section are all that are needed, see Fig. 7, or, that all information may be given on a single cross-section, see Fig. 8. In Fig. 9, showing the section of a gear, is found the common convention of not sectioning the arm, although the cutting plane passes through the arm. It will also be noted in Fig. 10 that when a section passes through pins, bolts, gear-teeth, etc., it is not noted but left blank. In drawing gear-wheels the teeth are generally not shown in outline, but only the pitch-circle and bounding circles are given. See Fig. 9.

In giving a sectional view, that which is seen back of the section may be shown, or it may not be shown, as it may seem better to do. The dimensioned drawing itself may not always convey the information needed to manufacture the part it represents, in which event it is customary to make notes on the drawing to give the specific information needed. Sometimes these notes are condensed into symbols. To illustrate the symbols and notes usually found on drawings, Figs. 11 and 12 are given.

Among the points to be noted in studying these drawings are the following:

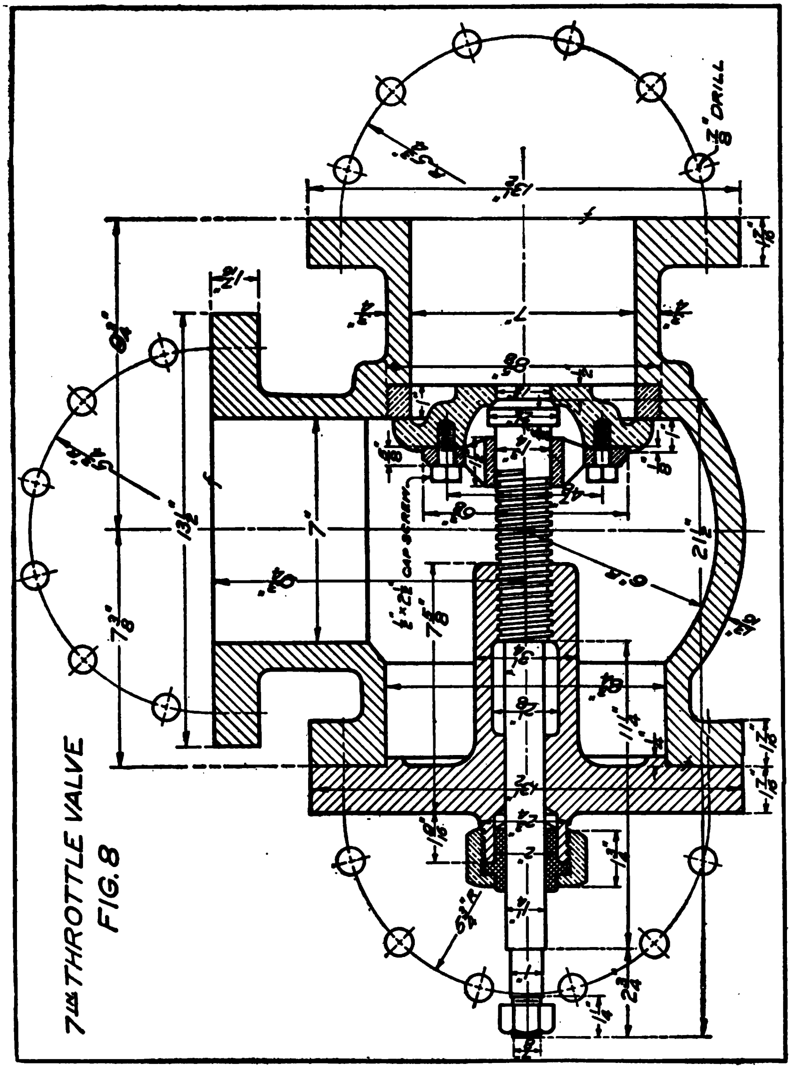
1. **General arrangement of views** that the drawing may have a well-balanced appearance. It is necessary that each view stand out distinct so that the drawing may be read at a glance.

2. **Lines.** The outline of the object should stand out clearly, which requires that these lines should be heavier than auxiliary lines used in dimensioning. It is required that different kinds of lines be used to distinguish the several purposes for which they are used on the drawing. Accordingly there will be found a certain conventional form for the center line, which form will be immediately associated with the fact that this line is an axis of symmetry. Dimension lines and extension lines are also seen to have different forms in order that they may be set off, with the result that the drawing is more easily read. The student cannot be too careful in observing every detail in the line conventions.

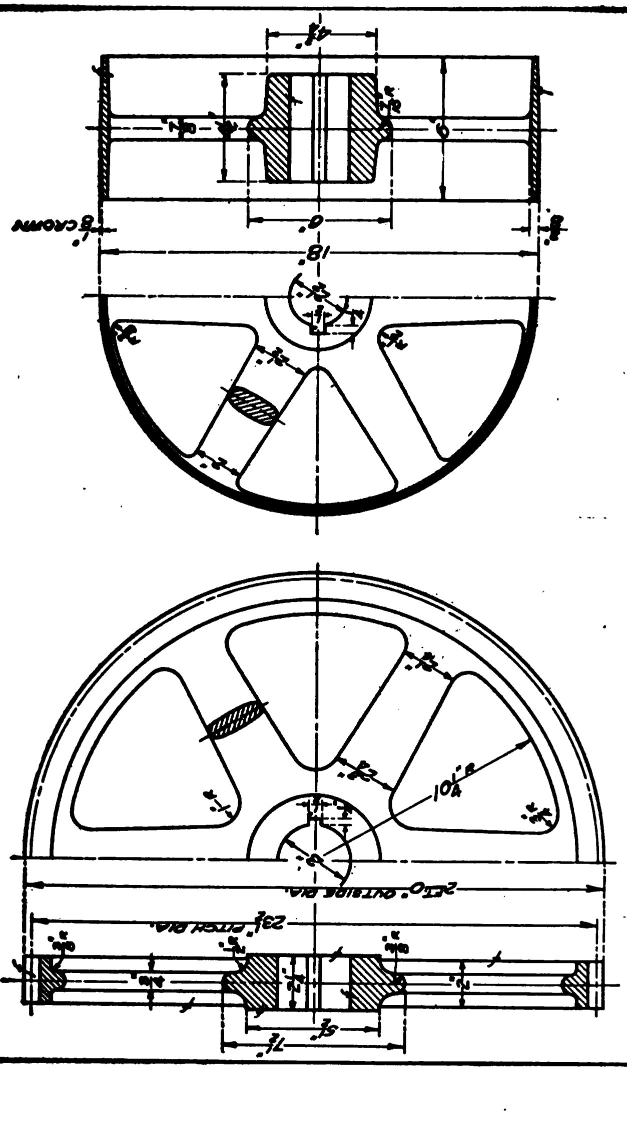


BRACKET FOR BRIDGE BEARING

FIG. 7



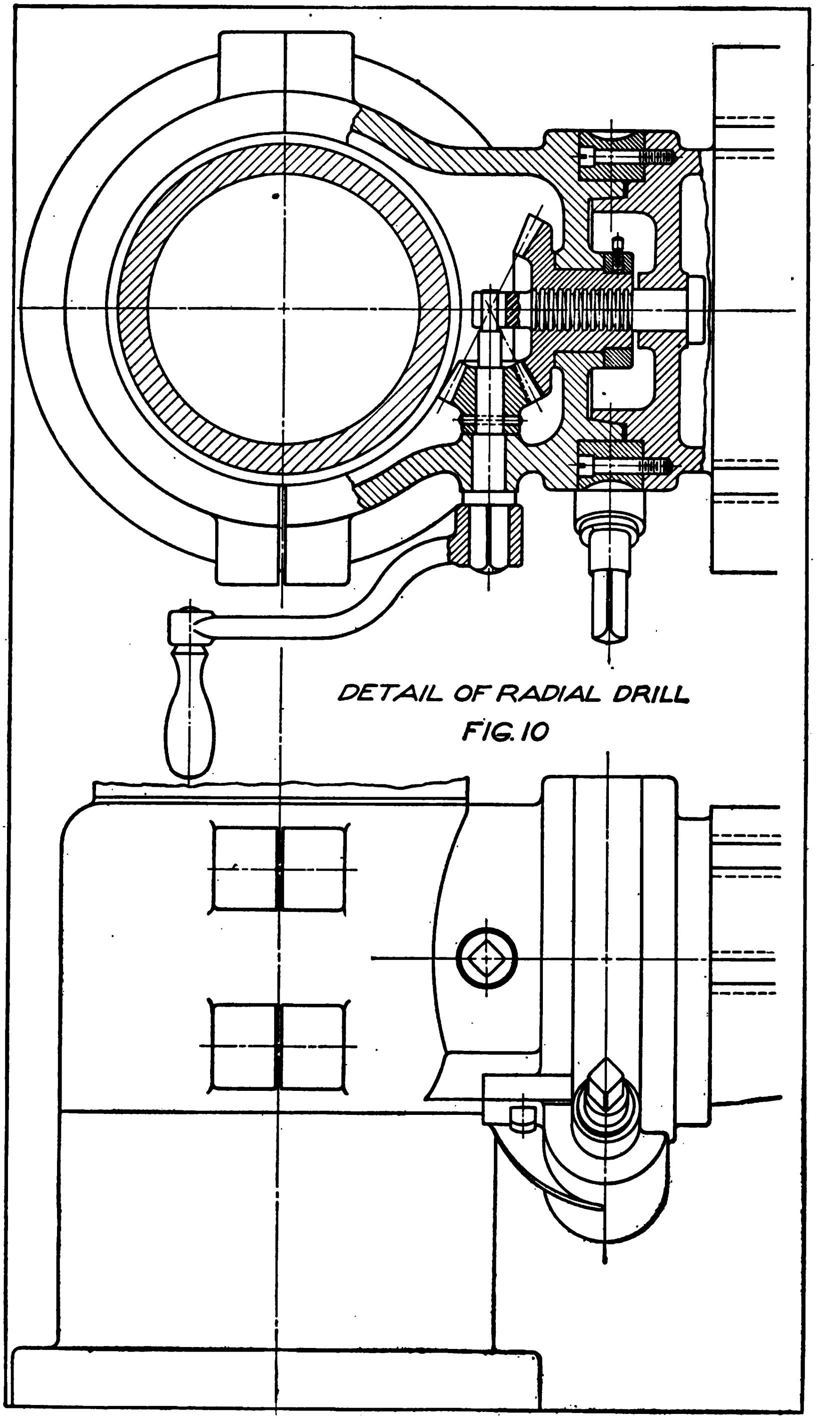
7 in THROTTLE VALVE
FIG. 8



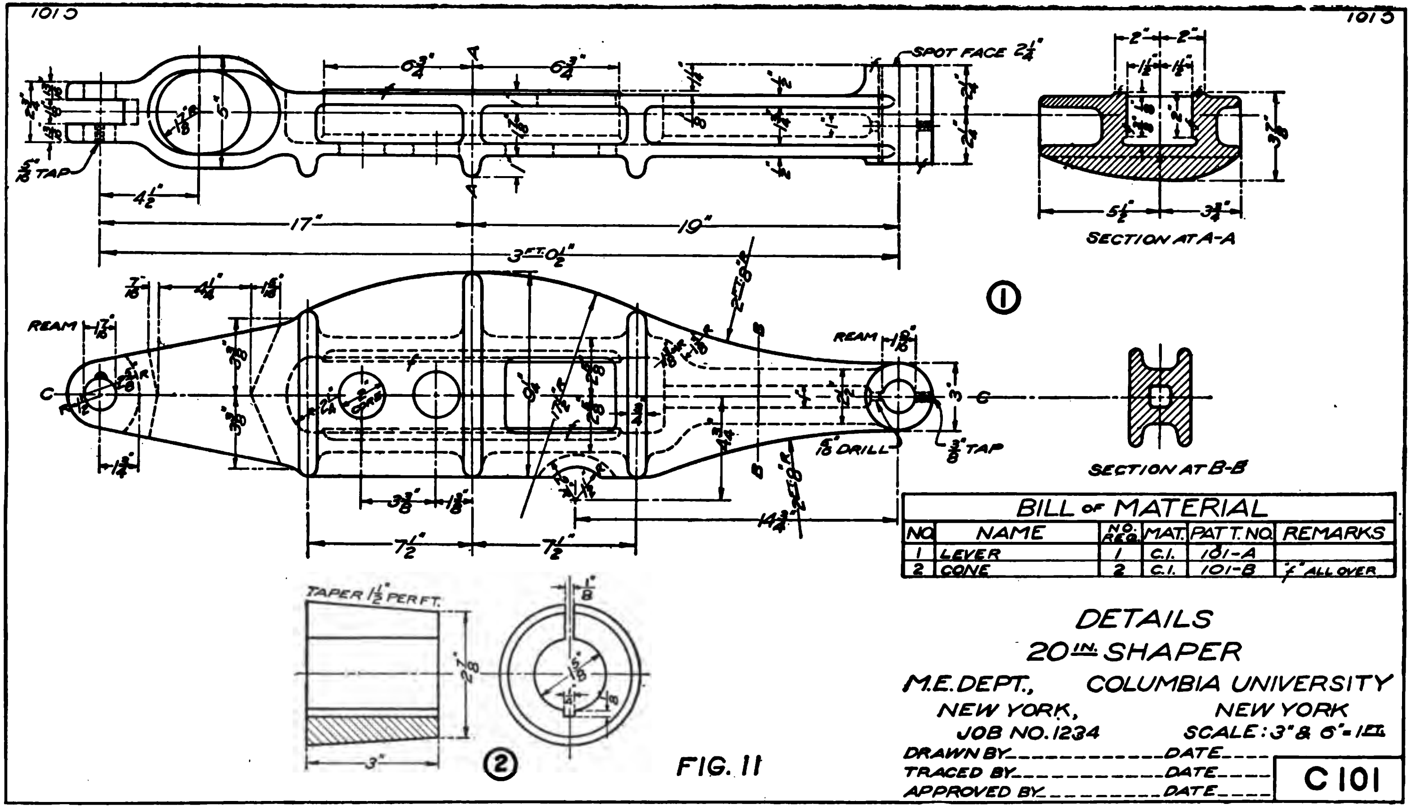
PULLEY

FIG. 9

SPUR GEAR-94 TEETH-4 PITCH



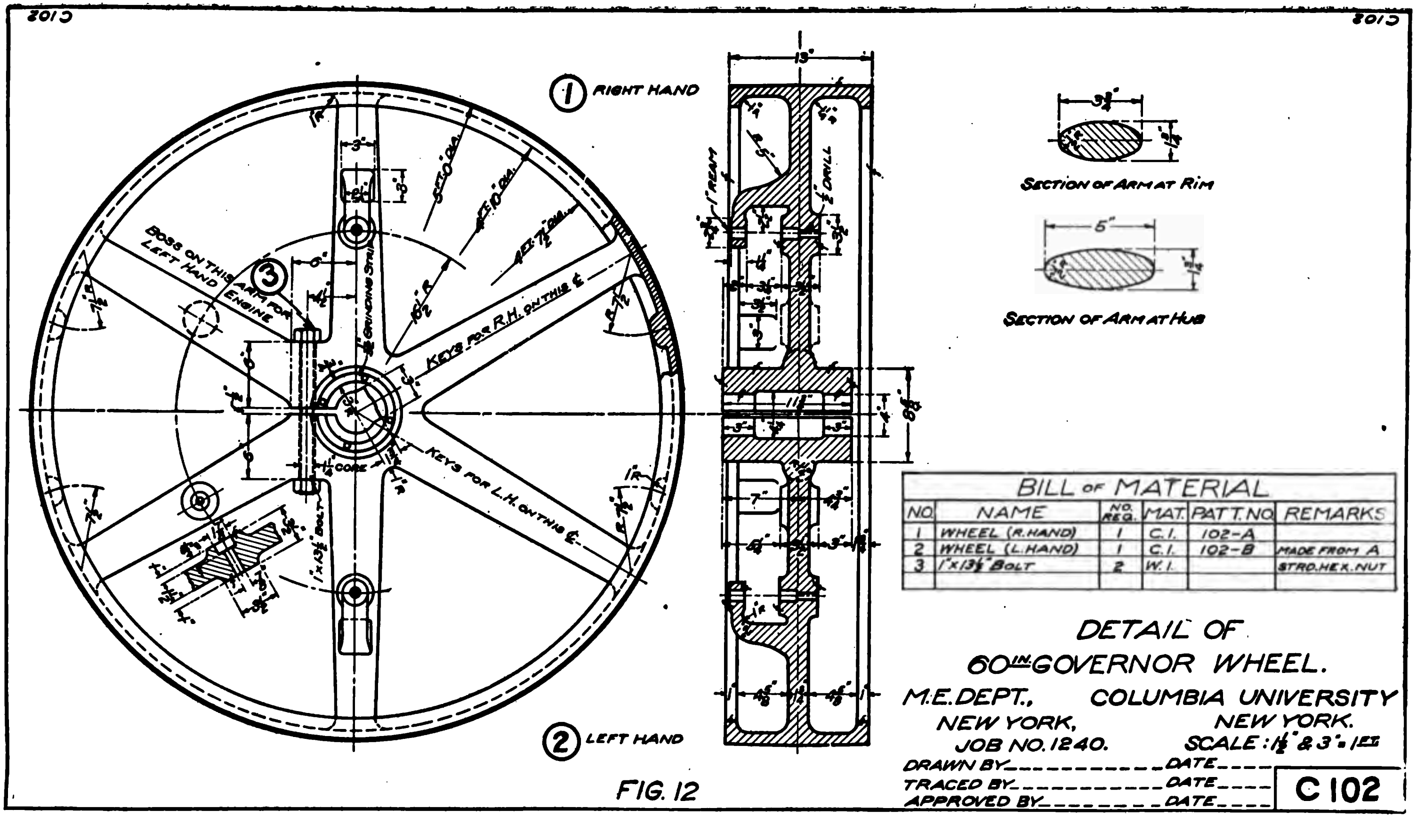
DETAIL OF RADIAL DRILL
FIG. 10



NO.	NAME	NO. REQ.	MAT.	PATT. NO.	REMARKS
1	LEVER	1	C.I.	101-A	
2	CONE	2	C.I.	101-B	f ALL OVER

DETAILS
20 IN. SHAPER
M.E. DEPT., COLUMBIA UNIVERSITY
NEW YORK, NEW YORK
JOB NO. 1234 SCALE: 3" & 6" = 1 FT.
DRAWN BY__________DATE____
TRACED BY__________DATE____
APPROVED BY__________DATE____
C 101

FIG. 11



BILL OF MATERIAL					
NO.	NAME	NO. REQ.	MAT.	PATT. NO.	REMARKS
1	WHEEL (R.HAND)	1	C.I.	102-A	
2	WHEEL (L.HAND)	1	C.I.	102-B	MADE FROM A
3	1"×13½" BOLT	2	W.I.		STRD.HEX.NUT

DETAIL OF
60IN. GOVERNOR WHEEL.
M.E.DEPT., COLUMBIA UNIVERSITY
NEW YORK, NEW YORK.
JOB NO. 1240. SCALE: 1½" & 3" = 1FT.
DRAWN BY__________DATE____
TRACED BY__________DATE____
APPROVED BY__________DATE____
C 102

FIG. 12

3. **General arrangement of dimensions.** Dimensions giving total distances, known as over-all dimensions, should be placed outside of subdimensions. Figures must be clearly written and not crowded, since they are the important features of a shop drawing. Dimensions must read from the bottom and from the right-hand side of the drawing. Arrow-heads on dimension lines should be small and neat. No dimensions are placed on center lines—in fact a center line should never be used but for the purpose for which it is intended. No lines of any kind should be drawn through a dimension figure. Dimension figures should be of the same size. In case a dimension is given in a cross-section, the section lines are broken sufficiently to permit the dimension figure to be placed. The dimension figure should be placed in the center of the dimension line. In case a center line passes through the center of a dimension line, as frequently happens, the center line should be broken in order to permit the dimension figure being placed in its proper position.

4. **Finishes.** A finished surface is one that is planed off or machined in some manner after it has been cast. Surfaces not marked "Finished" are left rough, just as they come from the foundry or forge. It is necessary to mark finished surfaces so that the pattern-maker or smith may allow the extra material taken off in the finishing. The machinist must also know which surfaces must be finished. It is customary to mark with the letter *f* the *profile* of a surface to be finished. This means an ordinary machine finish. If special finishes are required, they are called for by a note, such as grind, polish, etc. These special finishes are defined on page 34.

5. **Notes.** All notes should be made in letters of the same height, neatly executed. They should be written horizontally or vertically reading from the bottom, or right, but never written at an angle, for it spoils the looks of the drawing. Should be written close to the part referred to.

6. **Title and Bill of Material.** These are located in the lower right-hand corner of the sheet. The title should contain the information required to identify the drawing, such as general name of the parts drawn, name of the company; names or initials of draftsman, tracer, checker; scale to which the drawing is made; date when drawing is completed, and number of the job or contract; drawing symbol for record-keeping. The Bill of Material contains the names of the parts detailed on the drawing, reference number by which they are identified, number required of each, material of which each is to be made, pattern number for castings, and remarks of any particular nature that may be required. The name of each part appears in connection with a number which is placed on the drawing of this part, and is surrounded by a heavy circle so that it may be easily seen. Bolts, screws, etc., are purchased and carried in stock of standard sizes, and therefore do not have to be made in the shop, and when they are to be used with pieces detailed on the drawing they themselves need not be drawn but merely called for in the bill of material. They will bear a number, however, and be listed in the bill of material. This number will also appear near where the bolt or screw belongs, an arrow pointing to the exact location. The part numbered 3 in the bill of material of the drawing shown on page 13 will illustrate this point. Draftsmen are always informed on what is in stock, and are required to select stock sizes for screws, bolts, etc. A printed list is kept in the drafting-room for this purpose. It must be remembered, however, that bolts and screws, etc., may be "special" and not standard and carried in stock, in which case they are detailed as other pieces.

7. **Marking of Drawings.** In the lower right-hand corner in the title is found a mark by which the drawing is identified. This same mark appears in the upper left-hand corner, reading upside down, so that if the drawing should be placed in the drawer upside down, the mark could be seen and the drawing identified. As has been said, this mark is for the purpose of identification,

the items of the marking depending upon the system of recording used. For example, let us consider a company manufacturing four classes of machinery, such as shapers, drills, slotters, and boring-mills. In order to tell at once whether or not a drawing of some details is for any one of these machines, a "block" number may be assigned for drawings made for any machine. For example, all shaper drawings may be numbered consecutively from 101 to 400, all drawings for drills from 401 to 800, for slotters from 801 to 1200, and for boring-mills from 1201 to 1600. Four sizes of sheets are used on which the drawings are made, and the different-sized drawings are kept in separate filing-cases. Accordingly, then, a drawing will be lettered A, B, C, or D, according to its size. So that a drawing for one of the shaping-machines may be numbered B 126 or A 216, dependent on the size of sheet, for a boring-mill possibly B 1423, etc.

8. **Recording Patterns.** All patterns made in any shop are recorded and stored away when they have been used once, and they are frequently used again for filling another order or with some slight modifications are used on a different job. To facilitate the keeping of records of patterns each pattern must have a mark of identification. Ready reference must also be had to the drawing from which the pattern is made. For this reason the patterns occurring on any particular drawing may be marked consecutively with the letters A, B, C, D, or E, etc., together with the number of the drawing on which it is detailed. Thus in the bill of material under pattern number will be listed the letters A, B, C, or D, as assigned to the different patterns, and when the pattern is made it will have placed on it this letter together with the number of the drawing. This is the pattern number and it is listed in the pattern record-book. Thus on drawing 416, pattern C will have a pattern number 416 C. It will be noted that the size of the sheet on which drawing 416 is made is not given because it is not needed in identifying the pattern.

The above remarks will call attention to the important points to be observed in making a drawing. It must not be understood that all drawings found in commercial practice will be gotten up exactly as shown on pages 12, 13, but that these drawings embody the principal features to be found in all good drawings. In every well-ordered drafting-room there is established a system of conventions which each draftsman must rigidly adhere to. He receives these instructions in printed form. Gould & Eberhardt Co. of Newark, N. J., have kindly consented to the printing of their instruction sheets to draftsmen for the purpose of illustrating this feature of our text. It is given herewith without modification.

GENERAL STANDARDS

Sheets, standard size only, using 18×24 whenever possible. See Sheet No. 1.

All views projected in the third quadrant (angle), using the following scales: ¾″, 1½″, 3″, 6″, and 12″ to the foot, 1/16, ⅛, ¼, ½, and full size respectively. Scales should not read ⅛ size, but 1½″ per foot.

Use quarter-sectional views in preference to half-sections, and sectional breaks to facilitate the pattern-making of hidden parts.

Draw lines in accordance with sheet No. 2, also lettering and figuring as per same sheet, using black ink only, on dull side of tracing-cloth.

Draw all views necessary to completely illustrate, no more, no less, also in the same position they occupy on assembled machine.

For material abbreviations and cross-sections, see Sheet No. 3.

Use explanatory notes freely for clearing doubtful points. Stock parts to be used wherever possible, each part having name and number in accordance with stock system.

All drawings to have a separate and distinct title and number, which is to be entered in drawing record-book.

Everything must read from the lower and right side of sheet.

If the same pattern can be used for parts on different machines, a circle, with number of machine on which it is used, should be placed under title; this will eliminate duplications of patterns.

When there is a multiplicity of cast-iron or steel detail sheets, mark underneath the circle containing machine number, number of "Sheets," "Sheet No.", also giving latter number in title of sheet.

ROUTINE FOR DESIGNING NEW MACHINES

1. General drawing to be made, showing complete mechanism.

2. Complete assembled drawings made of the various mechanical combinations and contrivances to perform different functions of the machine. These drawings to be traced, and sent to the machine-shop to facilitate assembling of parts, and will also enable rapid detailing of parts, and checking of parts proper.

3. Detail of main and minor castings, bushes and change-gear lists, steel details and stock lists, made in the order named.

4. Complete assembled drawing of entire machine made (traced after construction of first machine); this must be carried out as if parts were being assembled in shop, using detail figures, which acts as a check on entire machine, and must continually be borne in mind as such.

5. Any standard attachments which may be required in the future to be provided for, and stock for same to be listed upon assembled tracing of attachment.

6. Erecting plan of machine to be made, showing everything required to erect same for operation; also cubical dimensions. Make outline drawing of machine.

Provisions for oiling to be made on all sliding surfaces, giving complete information.

Number of teeth and pitch to be given on all gearing, on both detail and assembly drawings, thus, "45 T. 10 P.", and driving direction of same marked on latter.

Use cast-iron bushes up to 400 ft. periphery speed, and composition bushes from 400 ft. up.

Bronze gears to be used where extra strength is required.

In designing spiral gears, select a normal circular pitch which has an even-spur diametral pitch, and avoid even circular pitches.

Example. Instead of using 0.5 normal circular pitch, use 0.5236, which equals a 6 diametral-pitch cutter.

DETAILING STANDARDS

In detailing parts having similar operations performed upon them, class together as much as possible, keeping steel and cast-iron parts on separate sheets.

Draw keyways in plan, marking width, depth, and length respectively, designating deep end when machine keys are used. See Sheet No. 12.

Draw solid keys in elevation, marking largest diameter necessary to machine said key. See sheet No. 1.

All bosses when faced, mark, counterbore generally ¼″ larger.

Draw all pin- and tap-holes in plan view.

All steel shafts, screws, etc., with the largest diameter collar of 3 inches or less should be made on the Jones & Lamson lathe and be marked as per sheet No. 1.

For button rounds, allow 1/16″ for shafts up to 1¼″, and ⅛″ from there on.

Shafts should project 1/16″ to ⅛″ beyond a rough surface.

All diameters to be kept in sixteenths of an inch (1/16″).

On detail parts a title should be placed above and fairly close to part. See Sheet No. 1.

Each part to have a name and number in accordance with adopted system.

Do not try to detail too many parts on one sheet, and see that ample room is allowed for necessary notes and dimensions for each part.

All small parts to be detailed full size and broken in length if necessary.

Make pencil drawings absolutely complete, and check carefully before tracing.

Compare tracing with pencil drawing, and see that figures correspond, before turning in as finished.

When bushing a hole whose face or faces are rough, use bushings ¼″ longer for casting variations; also place a note on drawing of same, thus: "¼″ allowed for matching up."

Where both faces are finished, bushings should be exact length.

For holding bushings of all standard sizes in place, use a ⅜ pivot-point headless screw.

When calling for screws or pins on drawings, designate as follows: 4×1¾ taper pin, or ¾×4½ cap-screw, etc.

Give part number of the thrust or other washer on detail of all parts, where they are used, to assist in locating them.

On all feed and speed tables, give formula which is deduced from the ratio of the constant geared train, mutiplied by the initial speed. So it will only be necessary to multiply the formula by the ratio of the change-gear combinations to obtain the resultant feed or speed. Also show how the formula was derived;

thus, $$400 \times \frac{15}{36} \times \frac{8}{32} = \frac{125}{3} = \text{formula.}$$

400 = initial speed, fractions represent gear ratios.

DIMENSIONING STANDARDS

Figure all dimensions generally in inches to about 50 inches, using the inch mark only, with 1, 6, and 9 without a fraction, and with dimensions in feet and inches. See sheet No. 2.

Dimension once only. Hardly ever repeat a figure, with the exception that when dimensioning holes, give clearest dimension on circle, also on view showing depth.

Most appropriate dimension on each view, similar parts dimensioned in like places.

Dimension from finish to finish after giving one important dimension from the rough with a note: "Begin sizes here."

Never place a dimension on center lines, and keep them clear of parts shown.

Shorter dimensions inside of longer ones, giving an over-all dimension on all parts.

Dimension drawings complete, so that patterns can be made from them, also tracings.

Distinguish machine-shop dimensions from pattern dimensions by placing a dot over the former. See Sheet No. 1.

Dimensions of bolt-holes should be as follows: $\frac{1}{64}$ larger from $\frac{1}{4}''$ to $\frac{5}{8}''$, $\frac{1}{32}$ from $\frac{5}{8}''$ to $1''$, and $\frac{1}{16}$ from there on. Also T slots.

Mark holes whether cored, bored, drilled, reamed, or ground. For reamed holes, see Sheet No. 2.

For tapped holes mark size of tap, number of threads per inch, left or right, acme or V thread, size of tap-drill, and standard screw-holes, marked thus: $\frac{5}{8}$ TAP, $\frac{33}{64}$ DRILL.

Mark number of threads per inch, acme or V thread, direction, right or left, and lead when multiple, for all threaded parts. See Sheet No. 1.

Mark limit allowance on part to fit within another, giving number of latter, parallel with axis of former.

Mark all radii for regular curves, and ordinates for irregular curves.

Finish marks on each view on lines representing finished surface, using the small letter *f*.

No dot is required for dimensions which have an explanatory note stating the operation to be performed; thus when calling for reamed, taped, or faced holes, etc.

ALTERATIONS

In altering a dimension of any kind, section same, and place new figure at its side.

If an entirely new part is added to machine, a new name and number must be created in accordance with adopted system.

To make any part obsolete on a tracing, cross-section same, and enter a note in lower 1½″ margin stating date of alteration, and reason for same.

Also alter each and every blue-print then in use. When this is done, foreman of the department where machine is being assembled must be notified of alteration.

All alterations (except change of dimensions which do not materially affect construction) must be noted in lower 1½″ margin, giving data and reason for same.

When a tracing becomes obsolete, mark same, also record same in record-book and place new number in "Replaced by" column in line with record of obsolete tracing.

When making a note in the 1½″ margin referring to changes make spaces 1″ wide.

On drawings where the parts drawn are out of scale with the figures upon it, a mark thus, X, should be placed before the figure. This will at once attract attention, when trying to scale the drawing and finding it does not coincide with the figures; also eliminate superfluous questions.

GUIDE FOR CHECKING DRAWINGS

1. You must know what is wanted before you go ahead with any checking.

2. See that the drawing is made in accordance with the system adopted, as to arrangement of views, title and number of parts, as well as title and drawing number, and that the design fulfills conditions required.

3. Check all dimensions by scaling, and by calculation whenever advisable.

4. See that each piece is correctly drawn, and that all views necessary are shown, but none that are not necessary.

5. See that dimensions for the shop are given as required by the shop; that is, that the shop is not left to do any adding or subtracting in order to get a required dimension.

6. See that all finished surfaces are properly marked and materials designated.

7. Check with previous drawings of similar apparatus, so that no new patterns are ordered when old ones already exist; also with stock parts.

8. Look out for interferences; this means check each detail with the piece with which it is to be assembled, and see that proper clearances have been allowed.

9. When checking for clearances in connection with mechanical movements, carefully lay out the movement to scale, figure the principal angles of motion, and see that proper clearances are maintained in all positions.

10. See that all screws, bolts, keys, pins, rivets, and any stock materials are according to standard sizes, and that stock is chosen whenever possible, and that a uniform size of bolts and nuts has been selected to reduce the number of wrenches required for the machine.

11. In a general way review the drawing as to any points that might have suggested themselves during the above checking. See that all entries have been made, such as record of drawing; that order blanks for castings, steel, screws, etc., have been correctly made; and bear in mind all the information given in standard-data book, as standard dimensions, stock sizes, example drawing, and abbreviations.

12. Make a record of all errors, to facilitate the correcting of mistakes.

Do not check any of your own drawings.

All tracings must be checked and signed by the checker before any print is made therefrom.

NOTE.—An error *is not* an error until *passed* by the checker.

It is advised that a similar plan be carried out in any courses arranged from this text, and the following conventions and instructions are given for that purpose. It has been the authors' experience that good results can be obtained only when the student is required to rigidly adhere to standards and conventions of some description.

CHAPTER II

CONVENTIONS AND STANDARDS

THE following conventions and instructions are to be followed in making all drawings:

1. The sizes of drawings shall be 9″×12″, 12″×18″, 18″×24″, and 24″×36″, with border lines one-half inch from each edge. These sizes are selected for the reason that commercial stock can readily be cut to these dimensions, and the smaller sheets can be cut from the larger without waste.

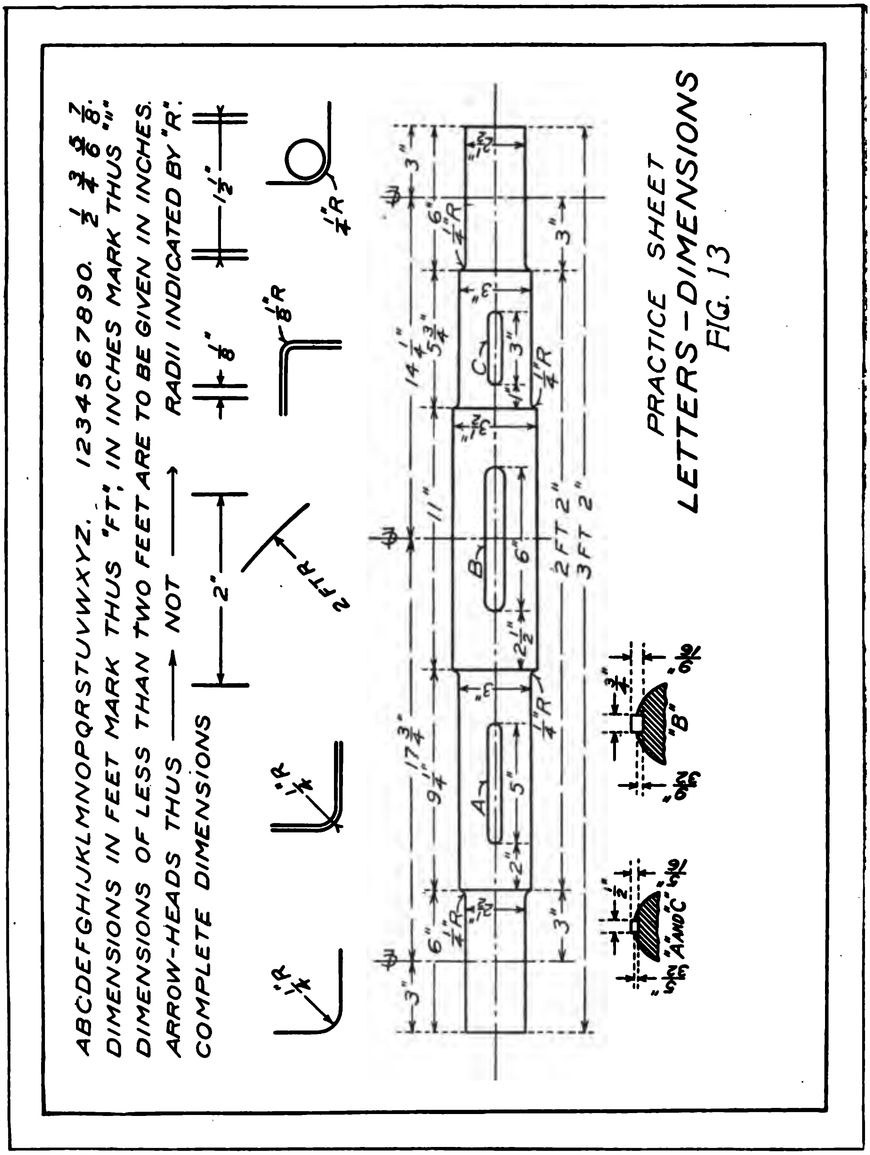
2. The letters and figures used for notes and dimensions shall be after the styles shown in Fig. 13. The detailed form of these will be found on pages 65 and 68.

3. All notes on drawings shall be made with letters $\frac{3}{32}$″ high and shall be made between very light guide-lines that distance apart. These lines are not to be reproduced on the tracing. Figures used in dimensioning shall be of this same height unless the space in which they are to be placed requires that they be made smaller. Fractions will be higher than whole numbers (see Fig. 13). Notes shall be written horizontally and vertically and not at an angle.

4. Lines of the kinds and weights shown in Fig. 14 are to be used as required.

5. Arrow-heads are always to be made as shown in Fig. 13. They should not be large and spread out, but with the barbs running into the dimension line.

6. Finish marks must be placed on the profiles of all finished



PRACTICE SHEET
LETTERS-DIMENSIONS
FIG. 13

surfaces. Special finishes, such as ream, spot-face, scraped surface, forced fit, etc., are to be called for by notes.

7. The Title and Bill of Material are to be laid out as shown in Fig. 14, and contain the items therein noted.

8. Each part shall bear a reference number whether the part is detailed on the drawing or is a standard part. Each number is to appear on or near the piece if detailed; if the part is standard, it is to be placed near where the piece belongs, an arrow showing the exact location. Each number is to be $\frac{1}{4}''$ in height and be placed within a heavy circle whose inside diameter is $\frac{3}{8}''$ and outside diameter $\frac{7}{16}''$. The number is to be made first and the circle drawn around it so that the number will appear exactly in the center of the circle. The number is to appear as heavy as the circle. The number shall appear in the bill of material with the name of the part.

9. The marking of the drawings shall be on the following basis. The size of the sheets shall be designated as A for 24″×36″; B for 18″×24″; C for 12″×18″; and D for 9″×12″. Drawings made in the first year shall be consecutively numbered from 101 to 199; in the second year, from 201 to 299; in the third year, from 301 to 399; and in the fourth year, from 401 to 499. Thus the first figure tells at once in what year the drawing is made, and the last figures give the consecutive number of the drawing. If required, this may further be divided by having all second-term drawings begin with 151, 251, etc. Thus if the eighth drawing made by a student in the second term of his third year be 18″×24″, it will be marked B 358.

Patterns will be listed A, B, etc., in the bill of material, whence pattern C on drawing B 358 will bear the pattern number 358 C. In the case of dies and such cases where it is convenient to at once associate castings belonging together, a second letter may be used. For example, male and female dies may conveniently be listed as C F and C M, and their pattern numbers will be 358 C F and 358 C M.

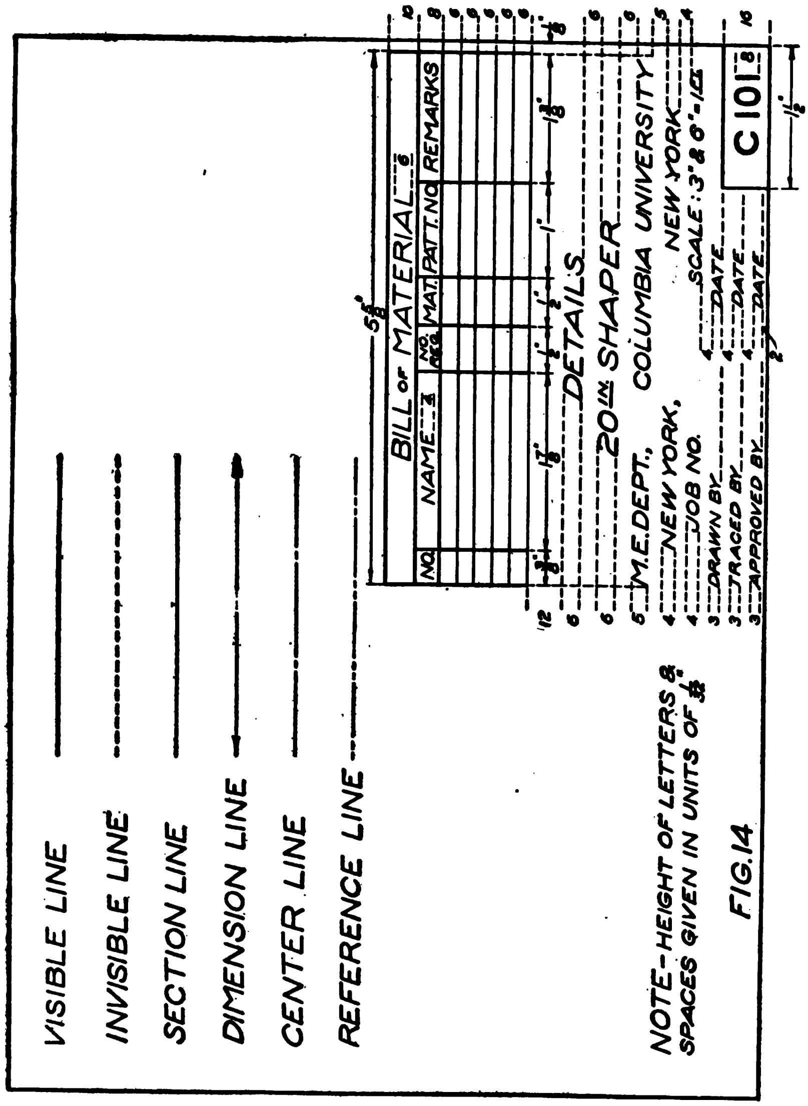

VISIBLE LINE
INVISIBLE LINE
SECTION LINE
DIMENSION LINE
CENTER LINE
REFERENCE LINE
BILL OF MATERIAL
NO.
NAME
NO. REQ.
MAT.
PATT. NO.
REMARKS
DETAILS
20 IN. SHAPER
M.E. DEPT., COLUMBIA UNIVERSITY
NEW YORK, NEW YORK
JOB NO.
SCALE: 3" & 6" = 1 FT.
DRAWN BY
TRACED BY
APPROVED BY
DATE
C 101
5 5/8"
1 1/2"
1 3/8"
1 7/8"
3/8"
1"
1/2"
NOTE – HEIGHT OF LETTERS & SPACES GIVEN IN UNITS OF 1/32"

FIG. 14

10. The standard proportions for bolts, nuts, screw-threads, etc., as shown in Fig. 15, will be adopted. The manner in which the bolts are dimensioned, and the size and number of threads per inch, are to be noted.

11. The various kinds of threads are as shown in Fig. 16. All threads will be shown conventionally as in Fig. 15. Unless noted, all threads will be considered U. S. standard V. Other threads to be called for by note. In the bill of material it should be noted if the thread is left hand (L. H.). If not noted it will be understood to be a right-hand thread.

12. Tapped holes and drilled holes are to be distinguished as shown in Fig. 19.

13. The U. S. standard for representing different kinds of material in section is given in Fig. 17.

Only the conventions for cast iron and babbitt metal will be used, for the reason that it is not general practice to use all these symbols, but to state in words what the material is. For this there is provided a space in the bill of material.

It is not the usual practice to cross-section shafts, keys, bolts, etc., the method of representation in such cases being as shown in Fig. 10.

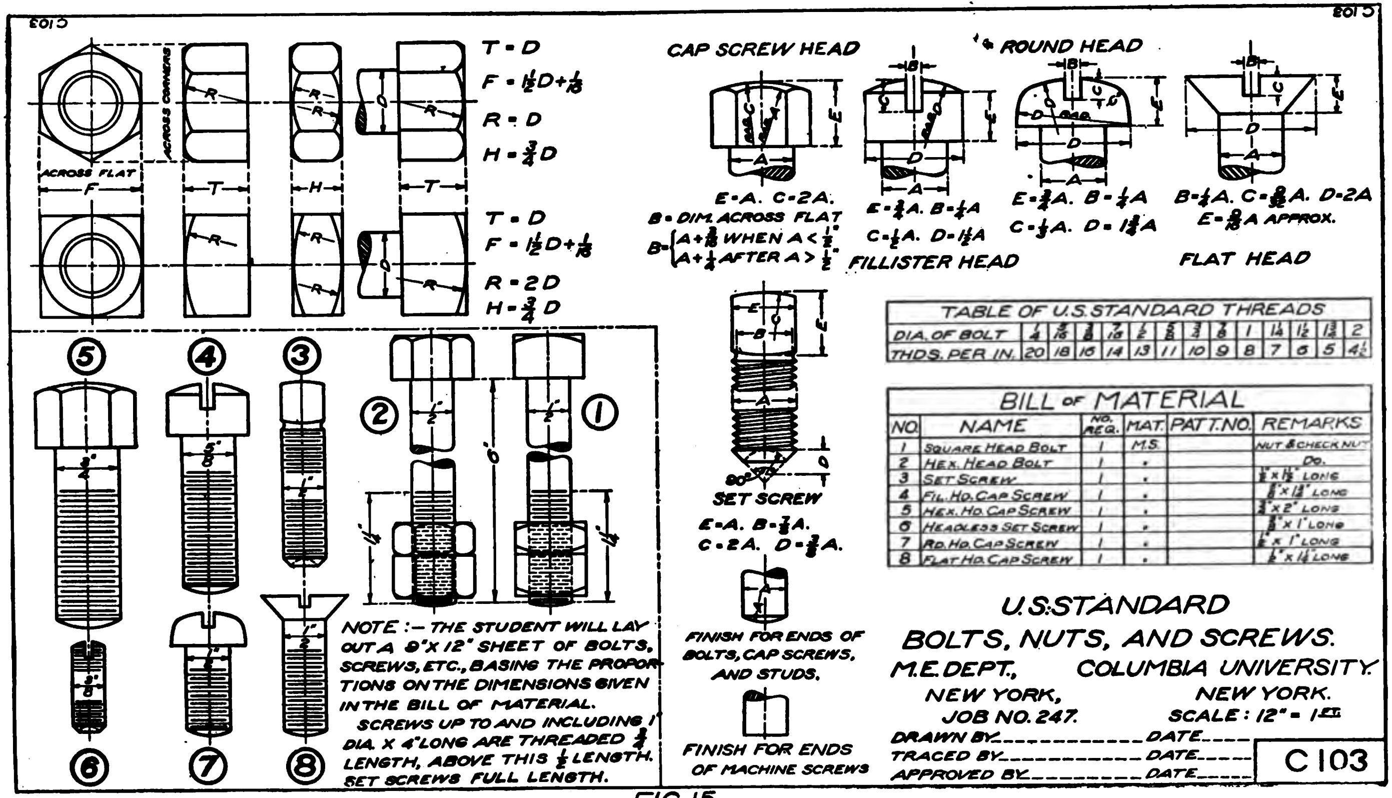
14. The electrical conventions shown in Fig. 18 will be used.

15. Every part to be cast shall bear a pattern number which shall be listed in the bill of material. See Article 9.

16. When two pieces are to be made, one right hand and the other left hand, only one is to be detailed, but there shall be a number for each which shall appear in the bill of material. In the remarks may be noted which is right hand (R. H.) and which is left hand (L. H.).

17. Adjacent parts not belonging to the part detailed but which when shown in their proper positions, with the part detailed, add clearness to the drawing, are to be shown in broken lines as illustrated in Fig. 19.

18. Alternate positions of a part in assembly drawings, which


C 103
ACROSS FLAT
ACROSS CORNERS
F
T
H
R
D
T = D
F = $1\frac{1}{2}$D + $\frac{1}{16}$
R = D
H = $\frac{3}{4}$D
T = D
F = $1\frac{1}{2}$D + $\frac{1}{16}$
R = 2D
H = $\frac{3}{4}$D
CAP SCREW HEAD
E = A. C = 2A.
B = DIM. ACROSS FLAT
B = {A + $\frac{3}{16}$ WHEN A < $\frac{1}{2}$"; A + $\frac{1}{4}$ AFTER A > $\frac{1}{2}$"
FILLISTER HEAD
E = $\frac{3}{4}$A. B = $\frac{1}{4}$A
C = $\frac{1}{2}$A. D = $1\frac{1}{2}$A
ROUND HEAD
E = $\frac{3}{4}$A. B = $\frac{1}{4}$A
C = $\frac{1}{3}$A. D = $1\frac{3}{4}$A
FLAT HEAD
B = $\frac{1}{4}$A. C = $\frac{9}{32}$A. D = 2A
E = $\frac{9}{16}$A APPROX.
SET SCREW
E = A. B = $\frac{7}{8}$A.
C = 2A. D = $\frac{3}{8}$A.
90°
A
B
C
D
E
①
②
③
④
⑤
⑥
⑦
⑧
$\frac{1}{2}$"
$\frac{5}{8}$"
$\frac{3}{4}$"
$1\frac{1}{2}$"
6"
FINISH FOR ENDS OF BOLTS, CAP SCREWS, AND STUDS.
FINISH FOR ENDS OF MACHINE SCREWS
C 103

NOTE:— THE STUDENT WILL LAY OUT A 9"X 12" SHEET OF BOLTS, SCREWS, ETC., BASING THE PROPORTIONS ON THE DIMENSIONS GIVEN IN THE BILL OF MATERIAL.

SCREWS UP TO AND INCLUDING 1" DIA. X 4" LONG ARE THREADED $\frac{3}{4}$ LENGTH, ABOVE THIS $\frac{1}{2}$ LENGTH. SET SCREWS FULL LENGTH.

TABLE OF U.S. STANDARD THREADS

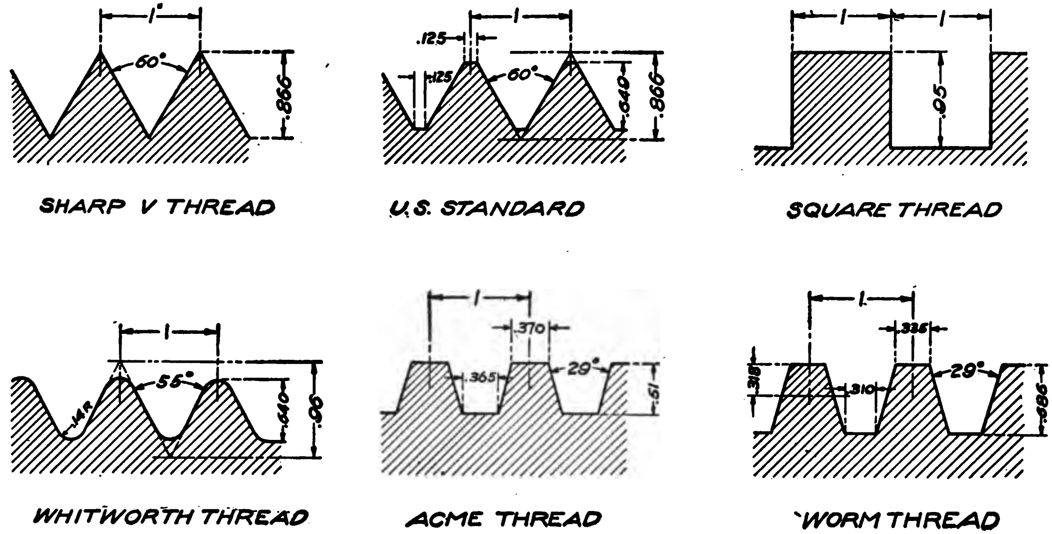
DIA. OF BOLT	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2
THDS. PER IN.	20	18	16	14	13	11	10	9	8	7	6	5	$4\frac{1}{2}$

BILL OF MATERIAL

NO.	NAME	NO. REQ.	MAT.	PATT. NO.	REMARKS
1	SQUARE HEAD BOLT	1	M.S.		NUT & CHECK NUT
2	HEX. HEAD BOLT	1	"		Do.
3	SET SCREW	1	"		$\frac{1}{2}$" x $1\frac{1}{2}$" LONG
4	FIL. HD. CAP SCREW	1	"		$\frac{5}{8}$" x $1\frac{1}{2}$" LONG
5	HEX. HD. CAP SCREW	1	"		$\frac{3}{4}$" x 2" LONG
6	HEADLESS SET SCREW	1	"		$\frac{5}{8}$" x 1" LONG
7	RD. HD. CAP SCREW	1	"		$\frac{1}{2}$" x 1" LONG
8	FLAT HD. CAP SCREW	1	"		$\frac{1}{2}$" x $1\frac{1}{4}$" LONG

U.S. STANDARD
BOLTS, NUTS, AND SCREWS.
M.E. DEPT., COLUMBIA UNIVERSITY.
NEW YORK, NEW YORK.
JOB NO. 247. SCALE: 12" = 1 FT.
DRAWN BY_____________DATE_____
TRACED BY_____________DATE_____
APPROVED BY_____________DATE_____
C 103

FIG. 15



SHARP V THREAD

U.S. STANDARD

SQUARE THREAD

WHITWORTH THREAD

ACME THREAD

WORM THREAD

NOTE — THESE PROPORTIONS ARE BASED ON THE PITCH, ASSUMED AS 1.

FIG. 16

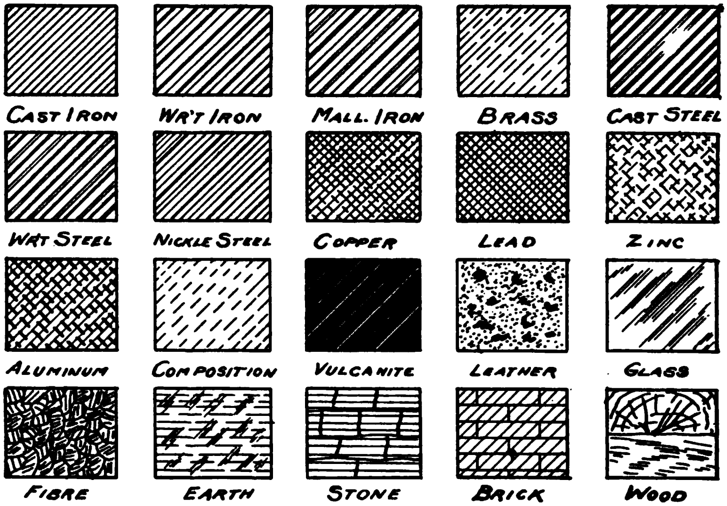

Cast Iron
Wr't Iron
Mall. Iron
Brass
Cast Steel
Wr't Steel
Nickle Steel
Copper
Lead
Zinc
Aluminum
Composition
Vulcanite
Leather
Glass
Fibre
Earth
Stone
Brick
Wood

FIG. 17

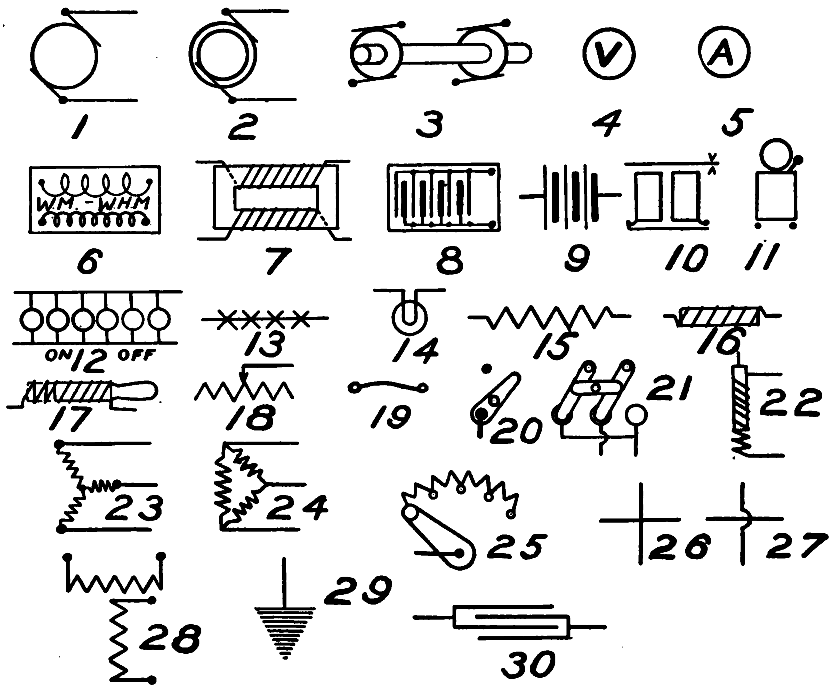


FIG. 18

1. Motor; 2. Alternator; 3. Motor Generator; 4. Voltmeter; 5. Ammeter; 6. W.M. Wattmeter, W.H.M. Watt-hour-meter; 7. Transformer; 8. Storage-battery; 9. Primary Battery; 10. Relay; 11. Bell; 12. Incandescent Circuit; 13. Arc-lamps; 14. Incandescent Lamp; 15. Resistance; 16. Reactance; 17. Adjustable Reactance; 18. Variable Resistance; 19. Fuse; 20. Switch; 21. Pole-changer; 22. Solenoid; 23. Triphase (Star Connection); 24. Triphase (Triangular Connection); 25. Rheostat; 26. Joined Wires; 27. Crossing Wires; 28. Two- or Quarter-phase; 29. Ground; 30. Condenser.

are often required to show clearance, etc., are shown in broken lines as seen in Fig. 19.

19. Knurled heads are to be as shown in Fig. 19.

20. Bearing surfaces on shafts are frequently shown as in Fig. 19.

21. End breaks are shown as in Fig. 19.

22. **Dimensions.** Dimensions shall be clearly written and not crowded. Base dimension lines from center lines and finished surfaces. Never place a dimension figure on a center line. All dimensions under two feet shall be expressed in inches. Dimensions in feet and fractions of an inch shall be written thus: $2'\text{–}0\frac{3}{16}''$. Never draw any kind of a line through a dimension figure. Just sufficient space shall be allowed for the dimension figure, and when a fraction is written the dimension line shall extend far enough to serve as the fraction dividing line. Be careful to give the dimensions needed by the mechanic and the pattern-maker in laying out the work. A series of holes equally spaced are dimensioned as shown in Fig. 19.

Tapers shall be dimensioned as shown in Fig. 11.

23. **Notes.** The notes usually found on drawings, and their significance, are as follows:

Finish.	Shape to dimensions with a cutting-tool, the surface to be such as good shop practice requires, but not to have anything on it for mere appearance unless specially stated. Usually denoted by an *f* on the profile of the surface.
Finish and Polish.	Shape to dimensions with a cutting-tool and make the surface smooth and glossy without destroying the accuracy of the work.
Finish and Smooth.	Shape to dimensions with a cutting-tool and make the surface smooth without destroying the accuracy of the work. A glossy surface is not called for.
Spot-face.	Make the spot true; this can be done with a counter-bore or similar tool, but does not call for measured adherence to dimensions.

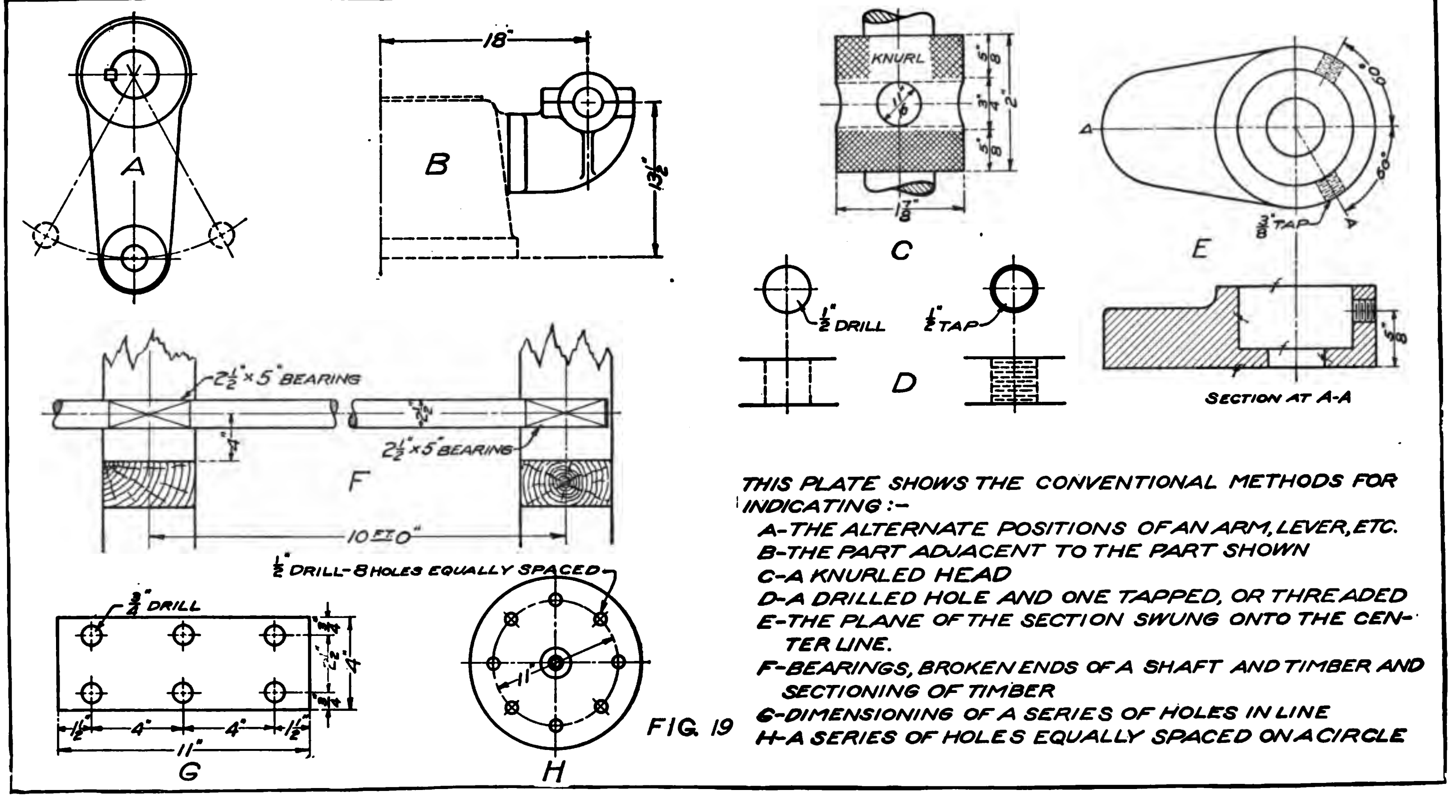


FIG. 19

THIS PLATE SHOWS THE CONVENTIONAL METHODS FOR INDICATING:—

A-THE ALTERNATE POSITIONS OF AN ARM, LEVER, ETC.

B-THE PART ADJACENT TO THE PART SHOWN

C-A KNURLED HEAD

D-A DRILLED HOLE AND ONE TAPPED, OR THREADED

E-THE PLANE OF THE SECTION SWUNG ONTO THE CENTER LINE.

F-BEARINGS, BROKEN ENDS OF A SHAFT AND TIMBER AND SECTIONING OF TIMBER

G-DIMENSIONING OF A SERIES OF HOLES IN LINE

H-A SERIES OF HOLES EQUALLY SPACED ON A CIRCLE

Trim.	Shape by any convenient means, such as chipping, filing, grinding, etc.
Grain.	Give the surface the appearance of having a straight grain. An example of a grained surface is that produced by rubbing with emery-cloth in a direction parallel to one edge.
Polish.	Make the surface smooth and glossy. When used without connection with the word "Finish" or the finish mark, neither a true surface nor measured adherence to dimensions is called for; such a polish may be produced by first grinding and then buffing.
Finish and Grain.	Shape to dimensions with a cutting-tool, and afterward grain without destroying the accuracy of the surface.
Finish and Scrape.	Shape to dimensions with a cutting-tool, and afterward increase the trueness of the surface by scraping.
Finish and Grind.	Shape to dimensions with a cutting-tool, and afterward increase the trueness of the surface by grinding.
Matt.	Cover uniformly with indentations touching one another and all of the same size, shape, and depth.
Blue.	Heat uniformly until the color changes to blue.
Nickel-plate.	Electroplate with nickel.
Drill.	Hole is to be drilled only.
Tap.	Hole is to be drilled and then tapped for a thread. This requires that the diameter of the drill used shall be equal to the diameter at the base of the thread.
Pipe-tap.	A special form of tap for tapered threads, used in fitting pipes.
Dowel or Dowel-pin.	A dowel-pin is a small pin set in a piece and used as a stop, or for matching, etc.
Running Fit.	This requires that the part be made to loosely fit over another part so that it can be easily moved or run without shaking. The bores of loose pulleys are turned with a running fit.
Drive or Pressure Fit. **Force Fit.**	This indicates that the part is to be made a trifle smaller than the part over which it fits, so that it must be forced into place and the two parts move as one. Car-wheels are usually forced on to the axles, and the bore of the wheel is made a few thousandths of an inch smaller than the axle.
T.P.I.	Threads per inch.

4 P. 24 T.	Indicates that the diametral pitch of the gear is 4 and there are 24 teeth. The diametral pitch of the gear is the number of teeth per inch of diameter, whence in the above example the diameter of the gear is 6 inches.
Core.	Means that the hole is not to be drilled but to be made in the casting of the part and left rough as it comes from the foundry.
Ream.	Means that the hole is to be finished by cutting with a reamer.
Punch.	Indicates that the hole is to be punched to size.
Punch and Ream.	Indicates that the hole is to be punched smaller than size and reamed to size with a reamer.

A number of other notes will be found on drawings indicating processes of manufacture, such as *case-harden*, etc., as well as abbreviations for material to be used which readily explain themselves.

24. **Checking Drawings.** Drawings shall be checked for the following items:

See that all projections and sections are correct.

See that general conventions and standards have been observed.

See that bill of material is complete and correct.

Check all dimensions in regard to arrangement and accuracy.

See that title and drawing number are correct.

Check all notes for arrangement.

See that all finished surfaces are marked.

On assembly drawings check for interferences and clearances.

See that proper weights of lines and sizes of letters and figures have been used throughout, and that the drawing is correct in every detail.

CHAPTER III

SPECIMEN DRAWINGS

A NUMBER of drawings are here arranged with a view to having several selected for reproduction by the student. It is recommended that only such a number be given as is required for the student to gain experience in the use of his instruments, a knowledge of the conventions used, and a good understanding of the principles of projection.

It is believed that the only way of gaining a knowledge of the use of the instruments, their adjustments, etc., is by personal experience under the direction of the instructor. For this reason such instruction is omitted in this text. For the beginner it is quite necessary that the work be carefully done, with no omission of details. The following method has been found to give good results, and its adoption and enforcement are recommended.

Each pencil-drawing must be inspected by the instructor and checked with his initials before being traced. Each tracing must likewise be inspected and checked before being accepted. All corrections must be made complete before subsequent work is undertaken.

GENERAL INSTRUCTIONS

In making a drawing it is well to follow some general plan of work, and not draw here and there in a haphazard fashion. A few simple rules of procedure will be sufficient to guide the beginner along the right lines.

In laying out the drawing it is good practice first to draw in the border lines and block in the space required for the title and bill of material. This at once determines the space available for drawing and prevents encroachments on the space required for the title and border. The drawing should be built up about centers and center lines, if there are such, or from limiting dimensions, if that be more expedient. The positions of the center lines must first be determined in order that the drawing may come in a convenient position within the border. After the location and drawing of the center lines and the location of the principal centers, if there are such, the procedure depends very largely upon the nature of the drawing. Each case presents its own problem and there is no strict rule to be followed. Good judgment, which will come after a little experience, is the best guide to follow. For the beginner a little blackboard explanation by the instructor will be worth more than many pages of description, therefore such matter will be omitted here. One point, however, should be called to the attention of the student, and that is that, in laying out a drawing in pencil, fillets and other arcs joining straight lines are to be drawn in after the straight lines have been drawn. However, when the position of a line is determined as a tangent to a circle or an arc, the arc must be drawn first and the straight line brought to match. In tracing, arcs and circles are to be drawn first and the straight lines made to match. When the drawing has been laid out in pencil, the dimension lines may then be filled in and the dimension figures, notes, etc., written in. In tracing it is good practice to trace the drawing first and then put in the border, title, etc.

EXERCISES

It is suggested that the student be thoroughly instructed in the system of lettering to be used, and that he be able to make fairly good letters before the drawing is begun. It has been the authors' experience that instruction in a single system is all that is needed by the student. To practice on several alphabets and make fancy letters is a waste of time and defeats the purpose of this work. The authors have found that the plates of letters and figures found on pages 65 to 70, etc., when executed by the student will prepare him sufficiently for the work in drawing. These plates should be executed in pencil on ordinary sketching-pads with lines ruled in $\frac{1}{8}''$ or $\frac{1}{16}''$ squares. Good results have been obtained when the instructor goes through the construction of plates 1 and 4, pages 65 and 68, at the blackboard and points out the difficulties in the construction of each letter and figure. Plates shown on pages 67 and 70 should be executed in ink. Concerning the work in drawing, attention may be called to the fact that it is not only in the manipulation of the instruments that the student must gain experience in pursuing this work, but also he must be trained to think. Mere copying of drawings without exercising a knowledge of the principles of drawing is not a good practice to follow.

It has therefore been arranged to give a series of problems in projection, etc., in connection with the several plates which follow.

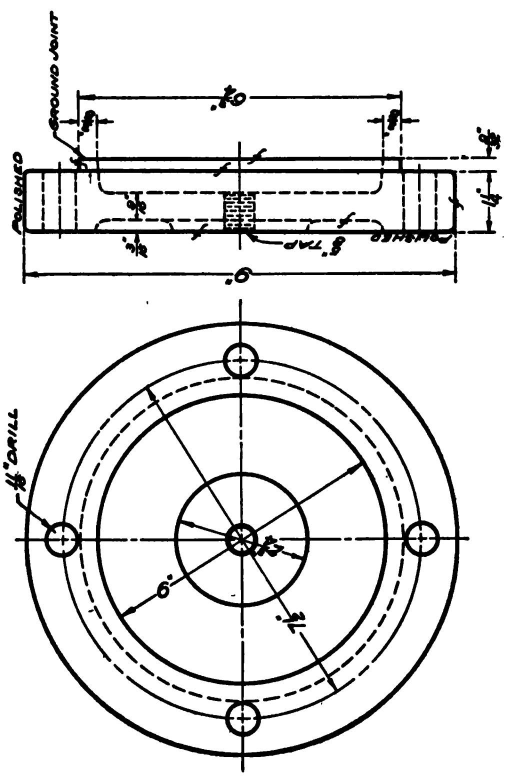
These drawings are to be made on some standard-sized sheet as assigned by the instructor, and be good working drawings with title, bill of material, etc.

PROBLEMS

The grouping of these problems on the different-sized sheets is left for the instructor to assign. The drawings are to be made complete in pencil and then traced.

1. Construct a drawing 9″×12″ containing standard proportions of bolts as shown in the lower left-hand corner of Fig. 15. Give complete title, bill of material, marking, etc.

2. Fig. 20 is the drawing of a cover-plate. Make a view of



COVER PLATE
FIG. 20

the face opposite to that shown, and a sectional view in place of the end view shown.

3. From Fig. 21 lay out a section of the valve-rod and head along the center line *C–C*, and a side view as shown.

4. From Fig. 22 lay out a plan as shown, and make a sectional view as cut by the vertical center line in place of the end view shown.

5. From Fig. 23 construct a view of the face opposite to that shown, and also a complete half-section in place of the side view shown.

6. From Fig. 24 lay out a view of the face opposite to that shown, and also views along the main horizontal and vertical center line in place of the side and end views shown.

7. From Fig. 25 construct a side view opposite to that shown, and in place of the top view as shown construct a sectional view along the line *A–A*.

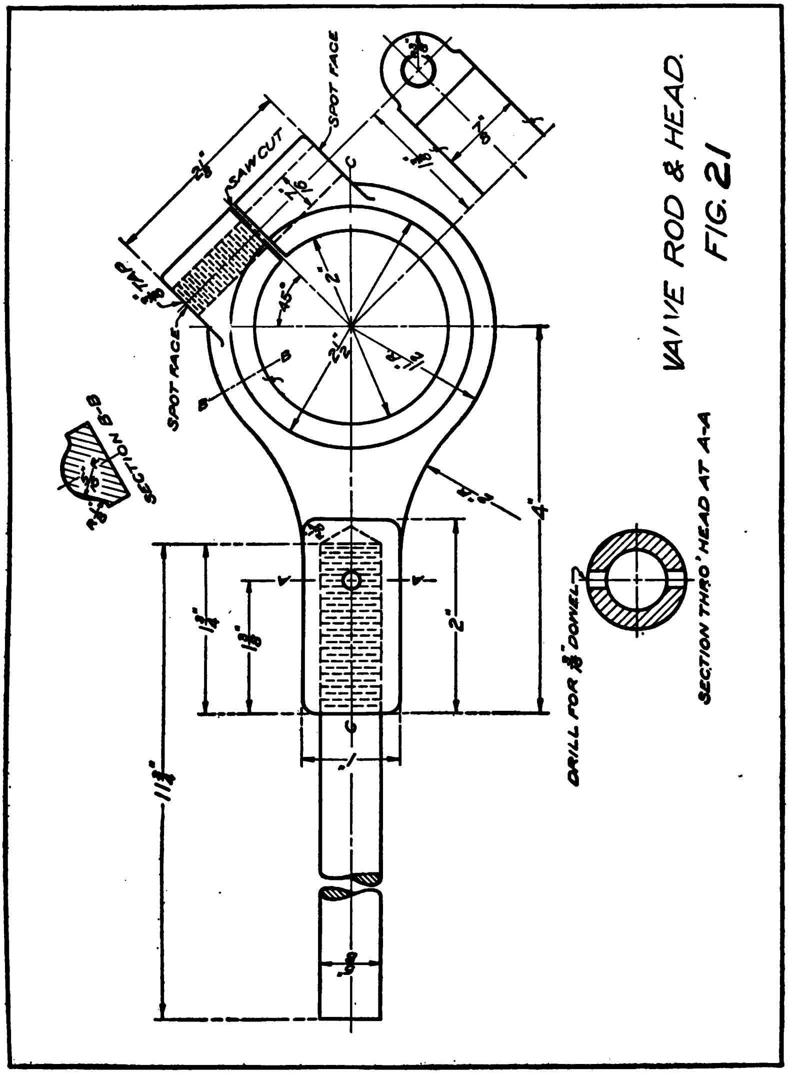
8. From Fig. 26 lay out the side elevation shown, and in place of the top view construct a sectional view along the vertical center line, and also a sectional view along a horizontal line through the center of the bolt-hole, a little above the line marked "Center line of car-wheel."

9. From Fig. 27 construct the front view as shown, and in place of the top view show a sectional view along the line *A–A*, breaking off the sectional view just above the dimension line giving the dimension (7″), and continue the view as given.

10. From Fig. 28 construct an end view opposite to that shown, and a sectional view through the vertical center line *A–A*, in place of the side view shown; also give a view of the section through *B–B*. Give a drawing of the key as shown.

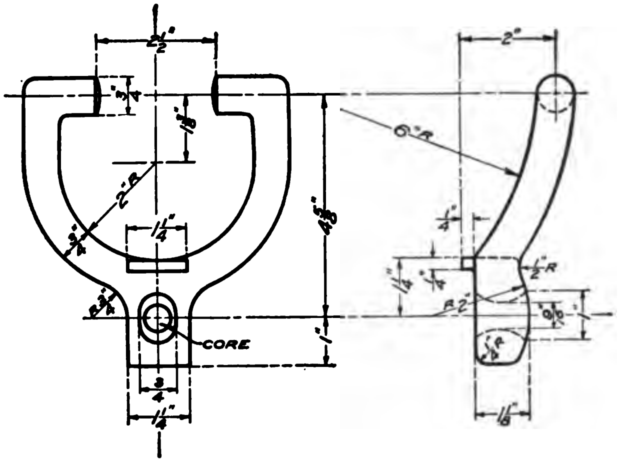
11. From Fig. 29 construct the plan view as shown, and in place of the side view construct a sectional view along the vertical center line.

12. From Fig. 30 construct the plan view as shown, and in place of the complete side view construct a sectional view along

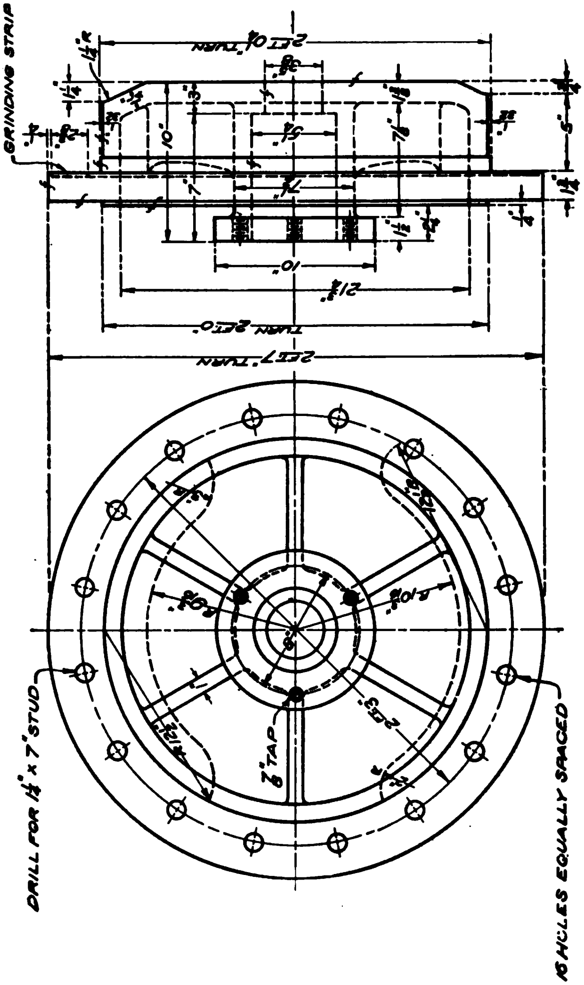


VALVE ROD & HEAD.

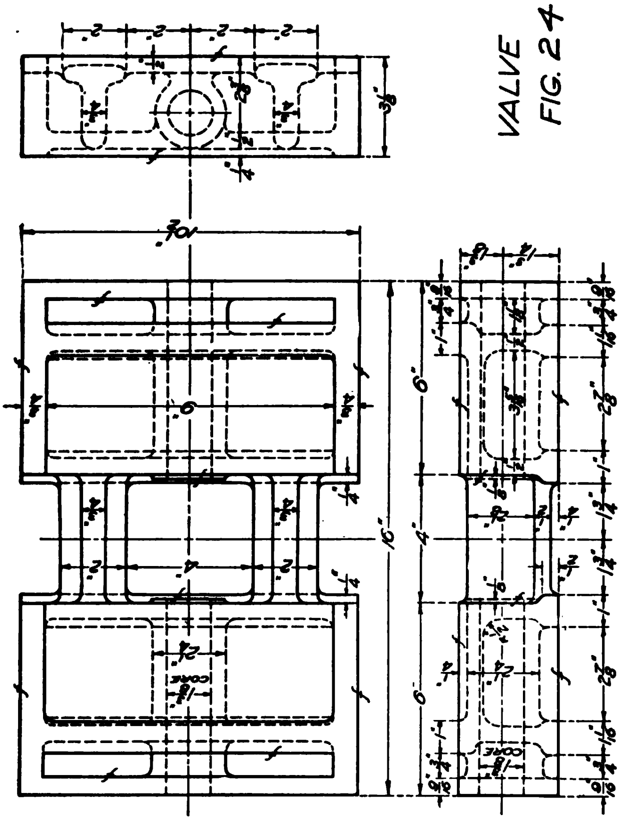
FIG. 21



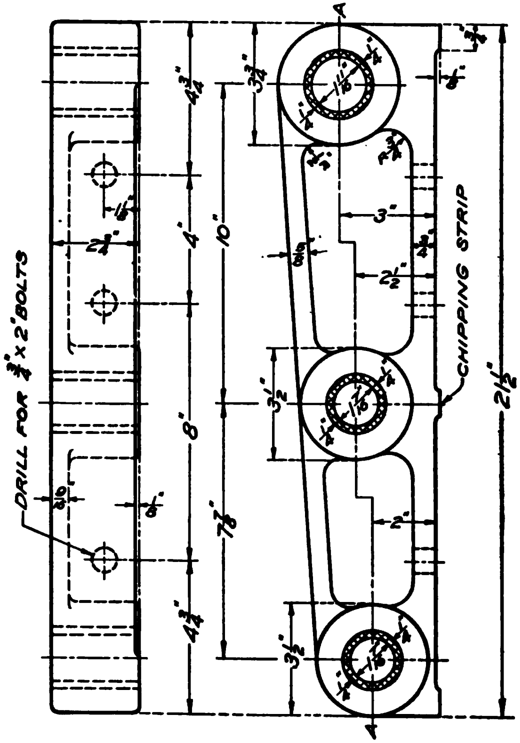
BRAKE LEVER
FIG. 22



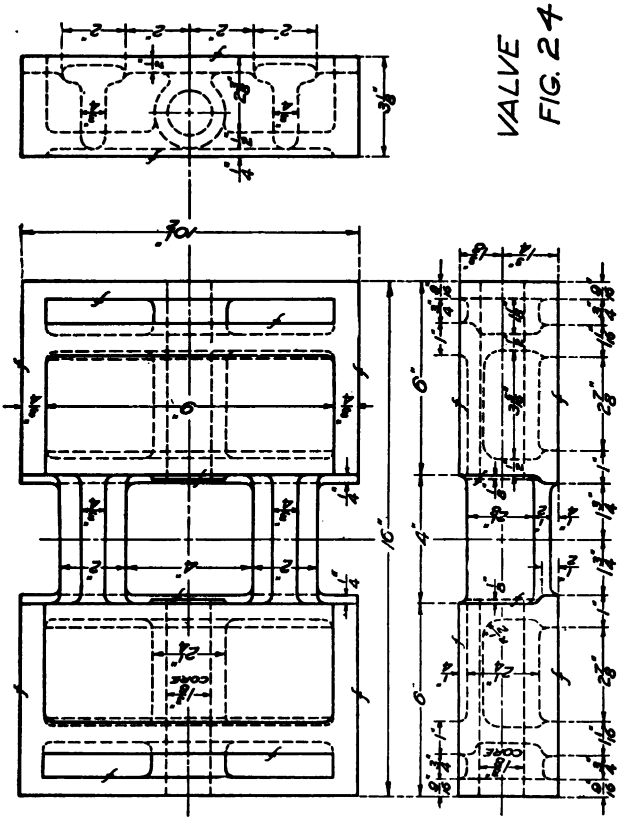
CYLINDER HEAD
FIG. 23



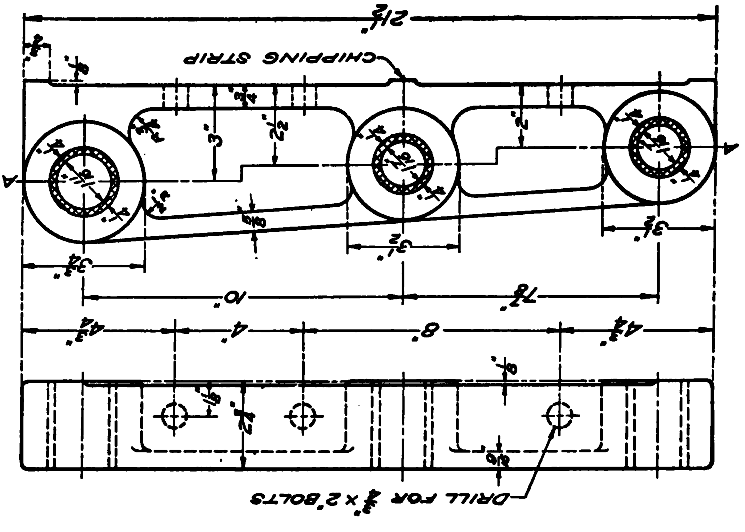
VALVE
FIG. 24



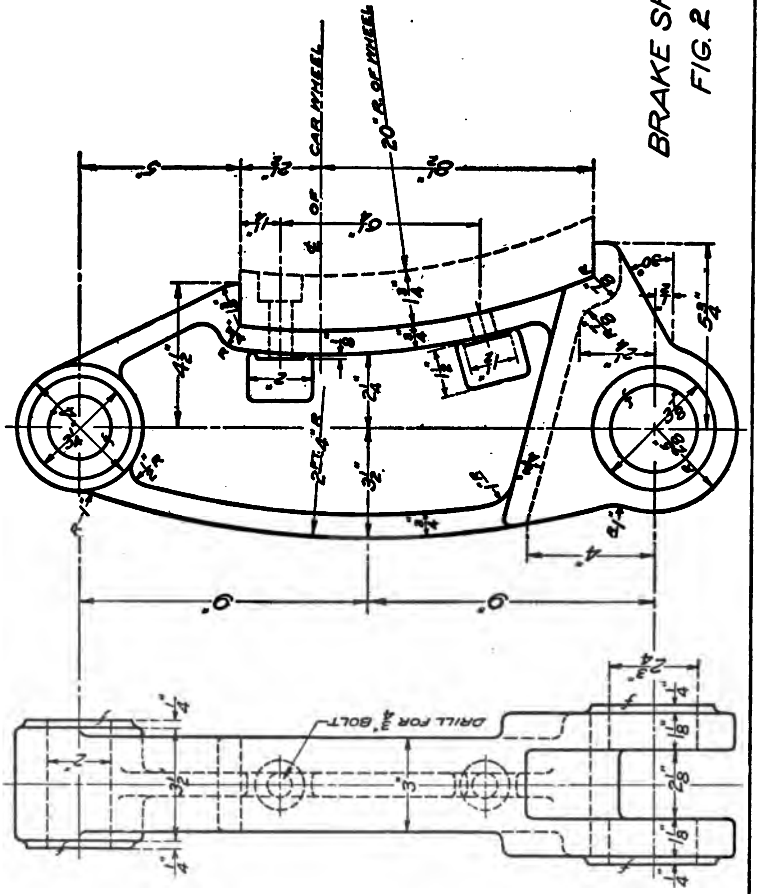
RIGHT HAND
WINCH FRAME
FIG.25



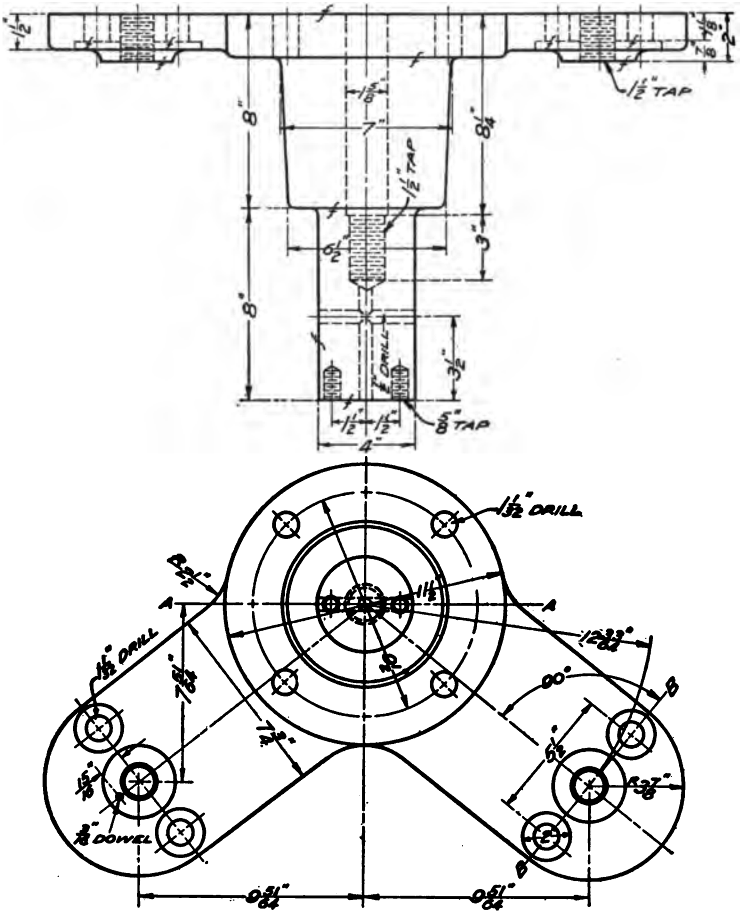
VALVE
FIG. 24



RIGHT HAND
WINCH FRAME
FIG. 25



BRAKE SHOE
FIG. 26



ROCKER SHAFT

FIG. 27

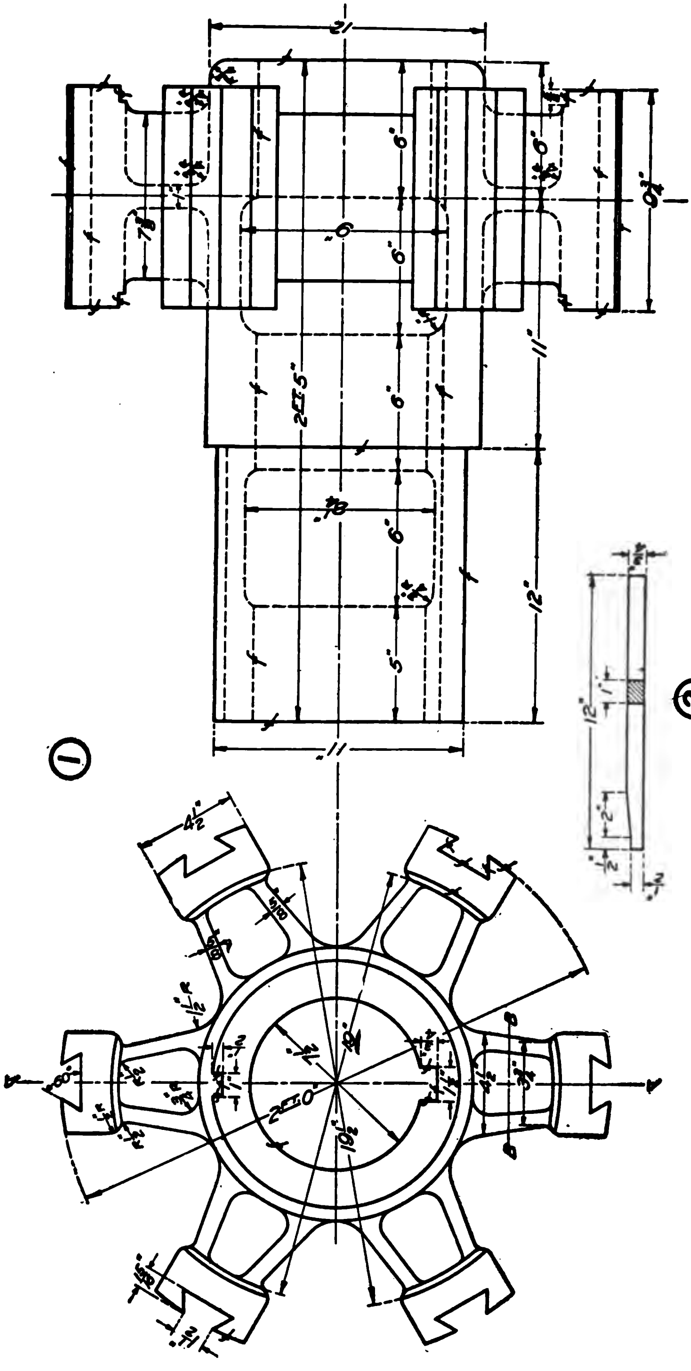
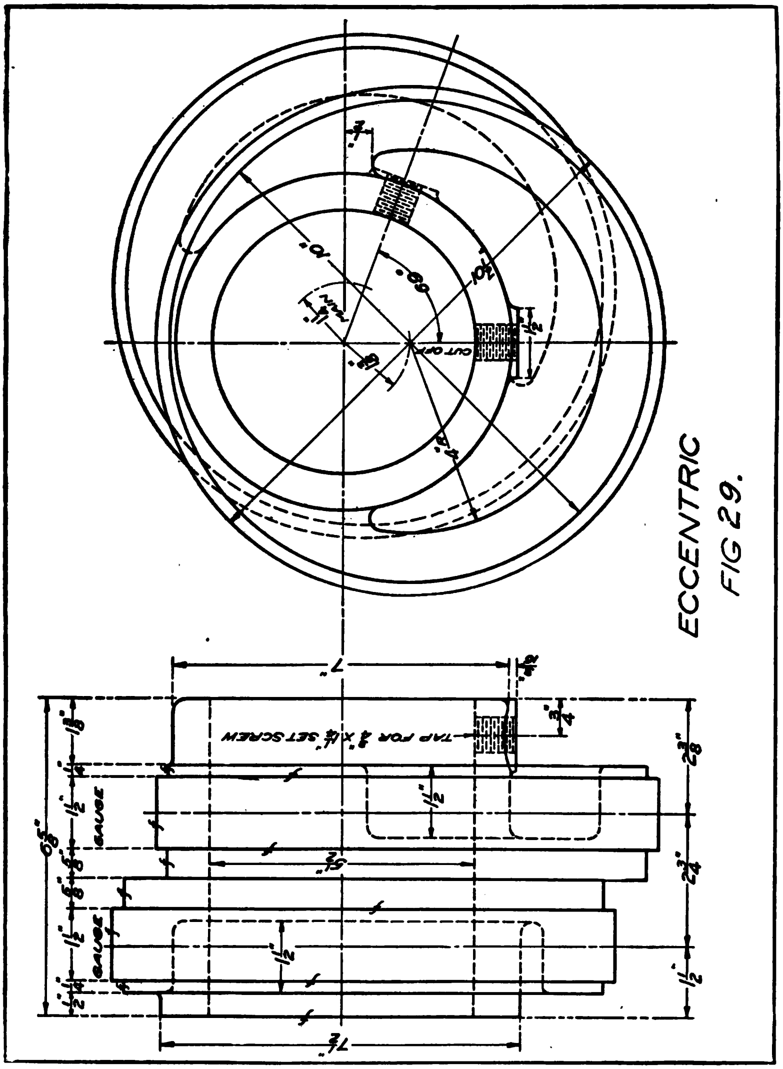
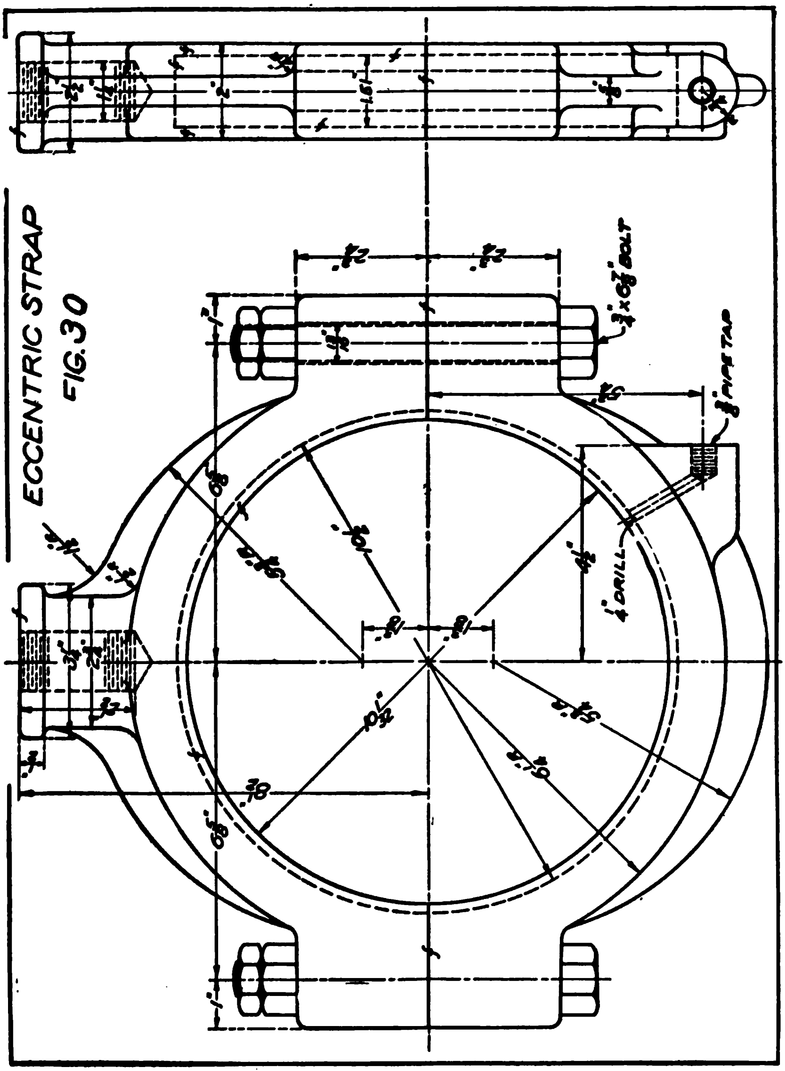


FIG. 28



ECCENTRIC
FIG 29.



ECCENTRIC STRAP
FIG. 30

the vertical center line from the rod hub to the horizontal line, from which place on, the view is to be a side view as given.

13. From Fig. 11 construct a drawing of the vibrating arm, giving, in place of the elevation shown, a drawing of the opposite face and, in place of the plan shown, a sectional view through the main center line *C–C*. Draw sectional views as shown.

14. Lay out Fig. 12 as shown.

CHAPTER IV

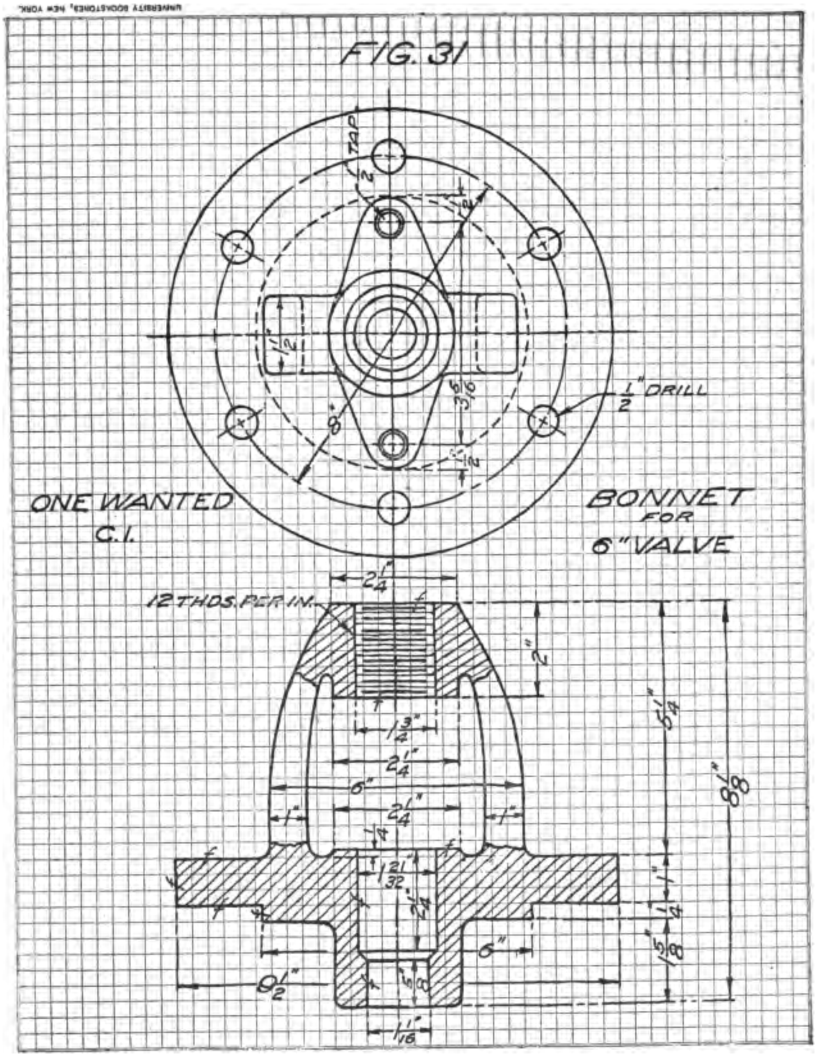
SKETCHING

QUITE often in commercial establishments a draftsman is required to go out into the shop and make a sketch of some machine part from which later a shop drawing is to be made. See Figs. 32 to 35. This may be done to replace a part that has been broken, or for which no drawing exists, etc. Also, in scheming out some details or general plans of design, it is necessary to sketch out preliminary arrangements that the problem in hand may be more thoroughly studied.

Sketching may be conveniently done on cross-section paper, since the lines assist the eye quite materially. A few general instructions may be given to guide one in making sketches from which drawings are to be made.

In the first place it may be well to note that sketches are not made to scale. All proportions are made by judgment entirely, and the dimension figures found upon measurement of the piece are depended upon absolutely. In preparing to make a sketch of a machine part it must be decided what views or sections may be required to clearly represent the piece. Make these views free-hand and in their proper position with respect to one another. Take no measurements during the progress of making the views. After the views have been completed, decide on the dimensions that will be necessary in making the piece. Imagine yourself making the piece and it will assist you in deciding as to what dimensions are required. Do not give measurements that would

FIG. 31


1/2 TAP
1/2
1 1/2"
3 5/16
8"
1/2
1/2" DRILL
ONE WANTED
C.I.
BONNET
FOR
6" VALVE
2 1/4"
12 THDS. PER IN.
2"
5 1/4"
8 7/8"
1 3/4"
2 1/4"
6"
2 1/4"
1"
1"
1/4
1 21/32
2 1/4
1"
1/4
1 5/8"
6"
9 1/2"
5/8
1 1/16"

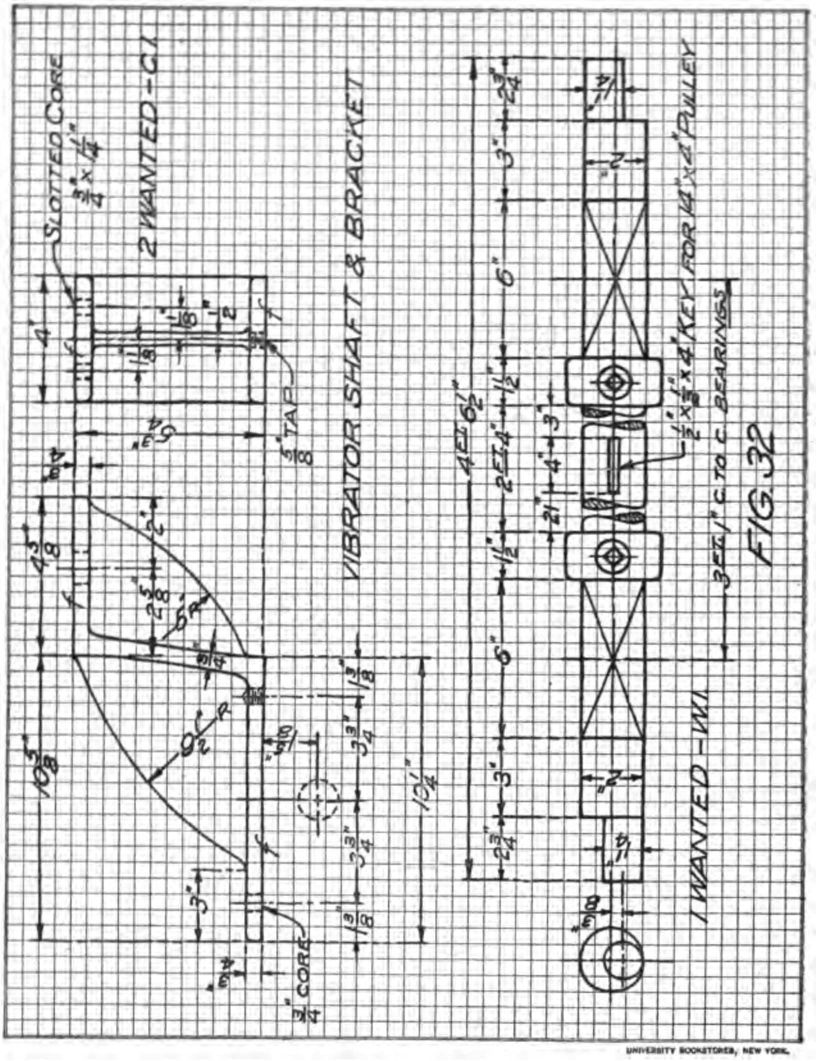
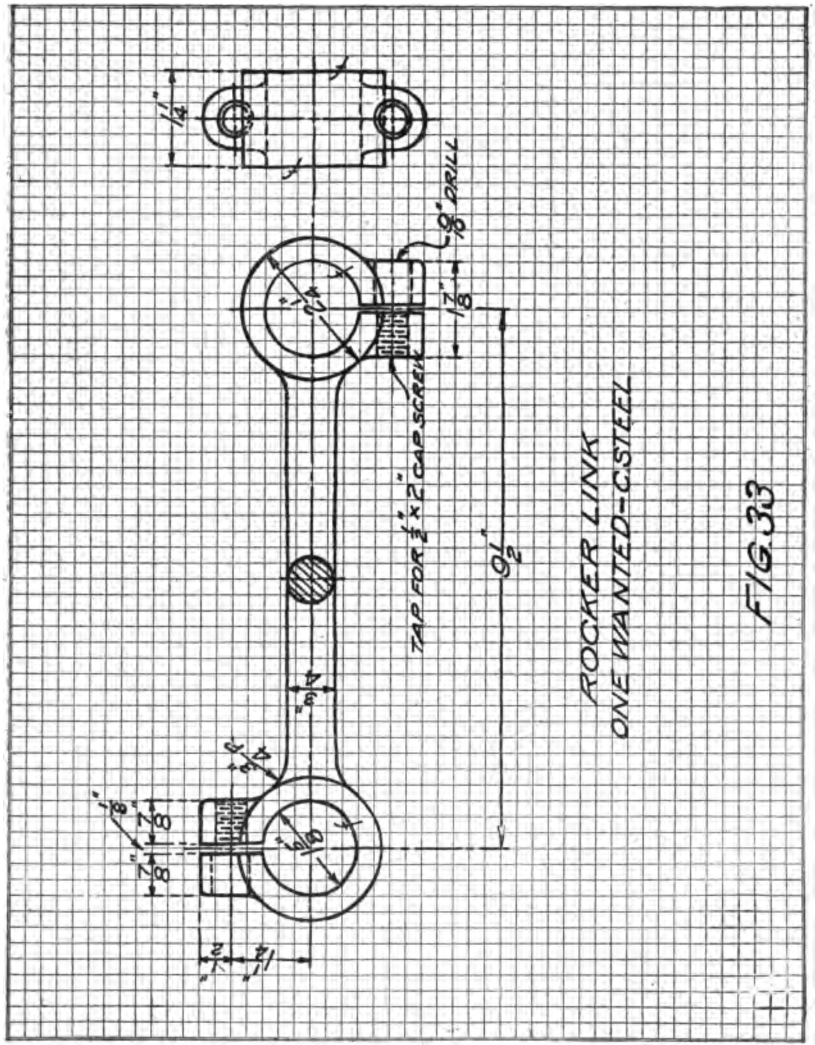

SLOTTED CORE
3/4" × 1/4"
2 WANTED - C.I.
VIBRATOR SHAFT & BRACKET
4"
1/8"
1 1/8"
1/2"
5/8" TAP
5 3/4"
3/4"
4 5/8"
2"
2 5/8"
6"R
5/8"
9 1/2" R
10 5/8"
3"
3/4"
3/4" CORE
1 3/8"
3 3/4"
3 3/4"
1 3/8"
13 1/4"
f
4 EQ. 6 1/2"
2 3/4"
3"
6"
1 1/2"
2 EQ. 4"
3"
4"
1 1/4"
2"
1/2" × 1/2" × 4" KEY FOR 14" × 4" PULLEY
3 EQ. 1" C. TO C. BEARINGS
1 WANTED - W.I.
UNIVERSITY BOOKSTORES, NEW YORK.

FIG. 32



ROCKER LINK
ONE WANTED-C.STEEL

FIG. 33

UNIVERSITY BOOKSTORES, NEW YORK.

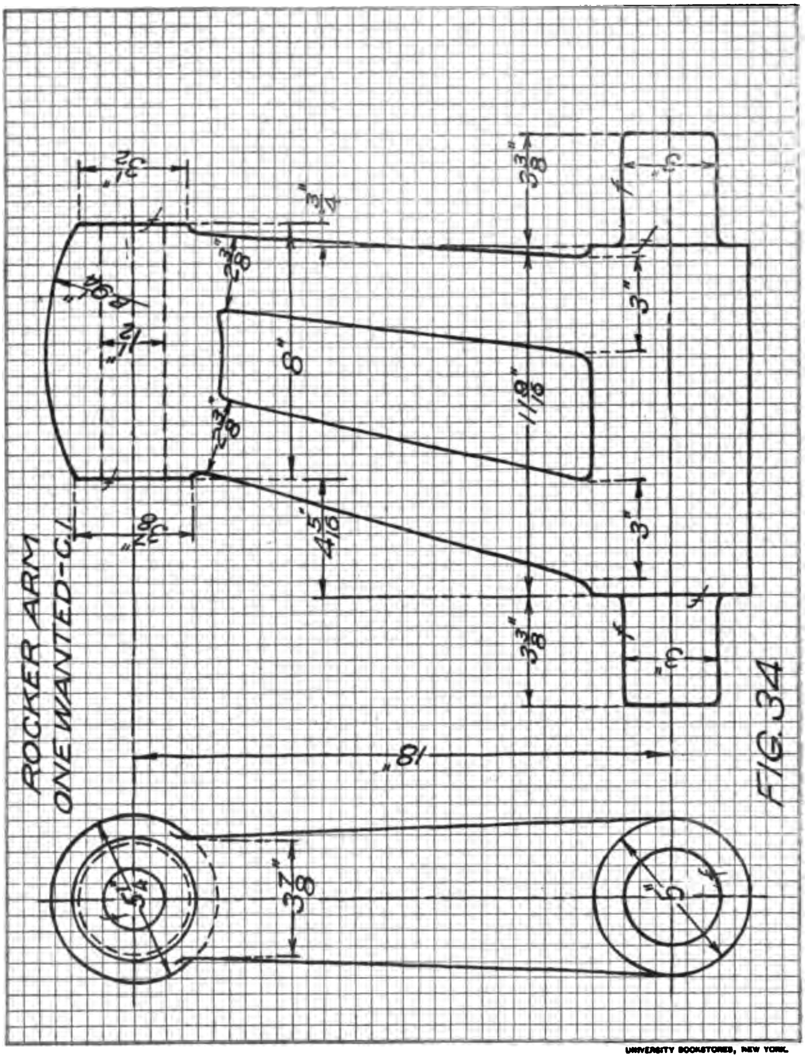


FIG. 34

UNIVERSITY BOOKSTORES, NEW YORK.

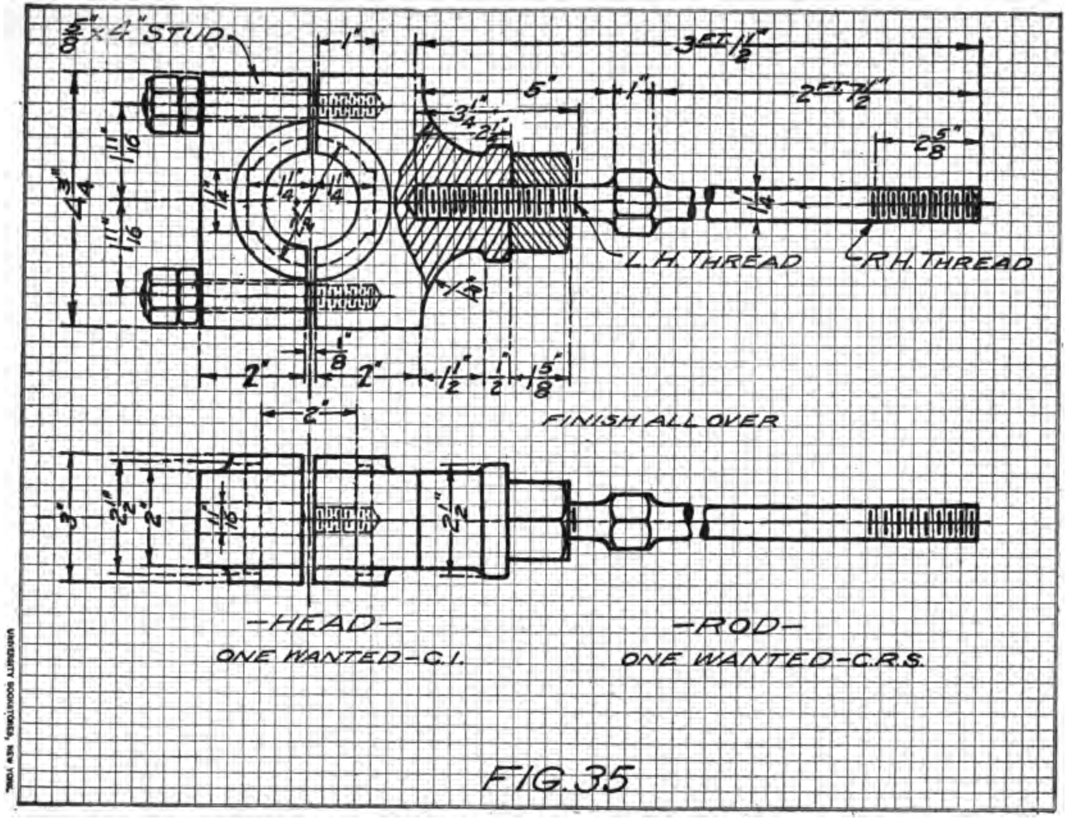


FIG. 35

UNIVERSITY BOOKSTORES, NEW YORK.

never be used by either the pattern-maker or the machinist. Draw in the extension lines and dimension lines as each dimension needed is decided upon, being careful to place them so that they may readily be understood. After this, measure these dimensions and insert the figures in their proper places. Write them carefully and measure accurately, so that any one else could make a drawing from the sketch without having to see the object itself. Fill in such notes as are required, mark finished surfaces, check up subdimensions with over-all dimensions, mark the sketch with the name of the part in the lower right-hand corner, and sign your name. Be sure to make sectional views of any parts difficult to understand, in order that the sketch may be easily and rapidly read. In making measurements of castings it must be remembered that patterns are made with some draft, to allow their being withdrawn from the mold. It may therefore be found that between two rough surfaces the dimension will be, say, $10\frac{1}{16}''$, etc., which should be interpreted $10''$, etc. The exercises to be given at this part of the work are a matter that depends very largely on the facilities at hand, and must be decided by the instructor. Any of the simple machine parts may be used, and the difficulty of the task assigned made dependent upon the ability of the student. A posted list of problems assigned will be sufficient for the conduct of this part of the work.

The amount of time allowed is a matter that must be decided by each instructor. The sketches shown on pages 55, 56, etc., are samples of good work not impossible of being duplicated by the student.

CHAPTER V

ISOMETRIC DRAWING

THE principles of isometric drawing may be applied to machine parts to give a clearer idea of the object drawn. Also in the laying out of pipe-lines, etc., it is very useful.

Choosing a particular piece of which an isometric drawing is to be made, the principles of the construction may be explained in the use of this example. Let it be required to make an isometric of the piece represented in the drawing shown on page 62, Fig. 37. Imagine the object enclosed by a parallelopiped and placed in the position shown in Fig. 38. The axes (*a*), (*b*), and (*c*) are known as the principal axes, and their position with the horizontal line is as shown; (*b*) being perpendicular to the horizontal, and (*a*) and (*c*) each at an angle of 30° with it. Measurements are made on these axes and those parallel to them, to scale, so that in this particular example on (*a*) would be laid off $1\frac{1}{4}''$ to scale, on (*b*) $2''$ to scale, and on (*c*) $2''$ to scale. It will be seen, therefore, that measurements along these directions are made just as in the case of a view in one plane. Proceeding, the distance 01 is laid off on (*c*) equal to $2''$, the length of the cylindrical portion, and at this point the plane 1–2–3 is constructed. Draw diagonals in this plane and the end plane, and connect the intersections by a line as shown in Fig. 38. This line joining the intersections is the axis of the cylindrical part of the object which is to be constructed as follows: Referring to Fig. 36, page 62, we have the isometric of a cube, having the inscribed circles on

FIG. 36

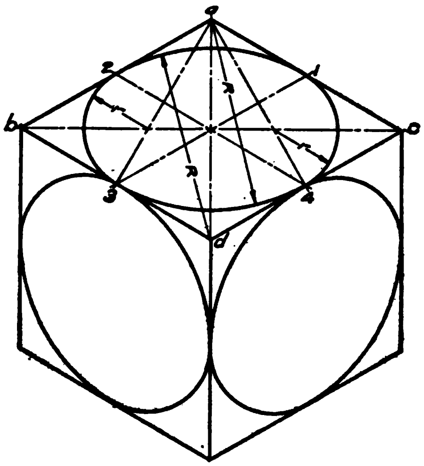


FIG. 37

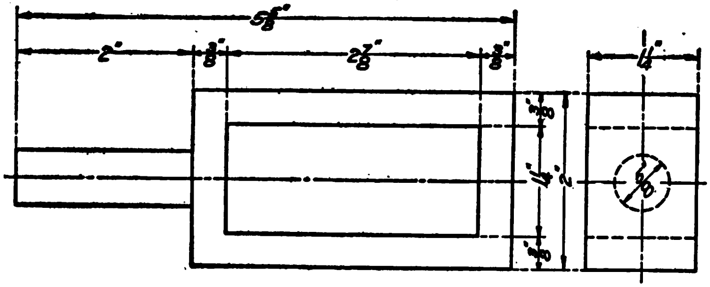
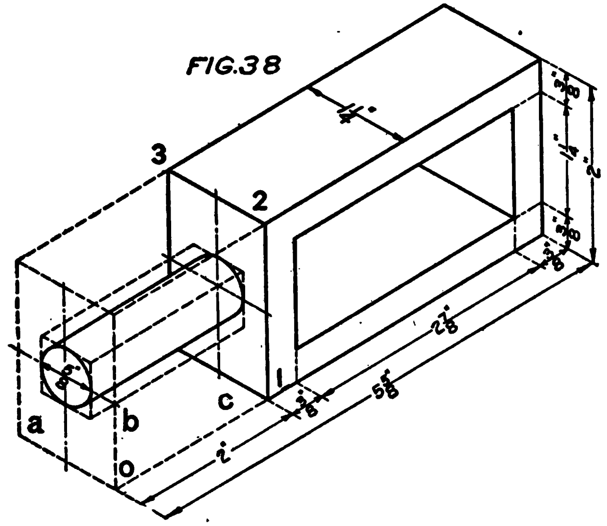
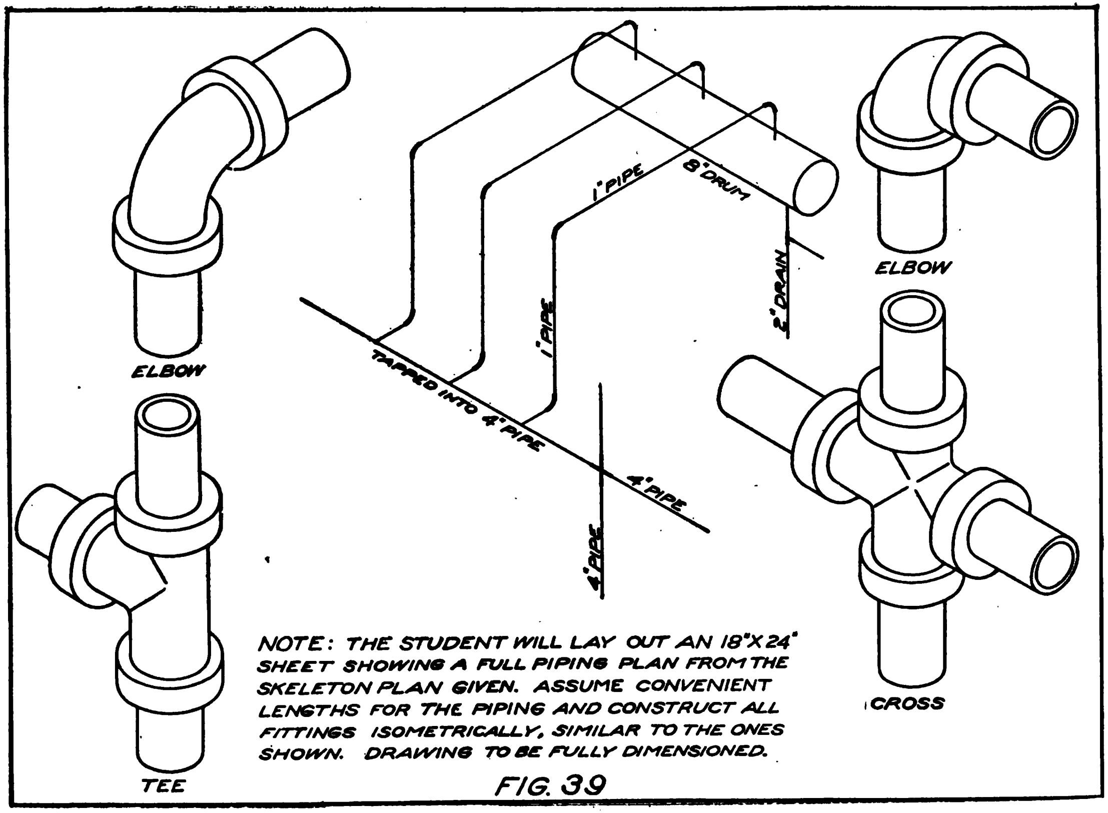


FIG. 38



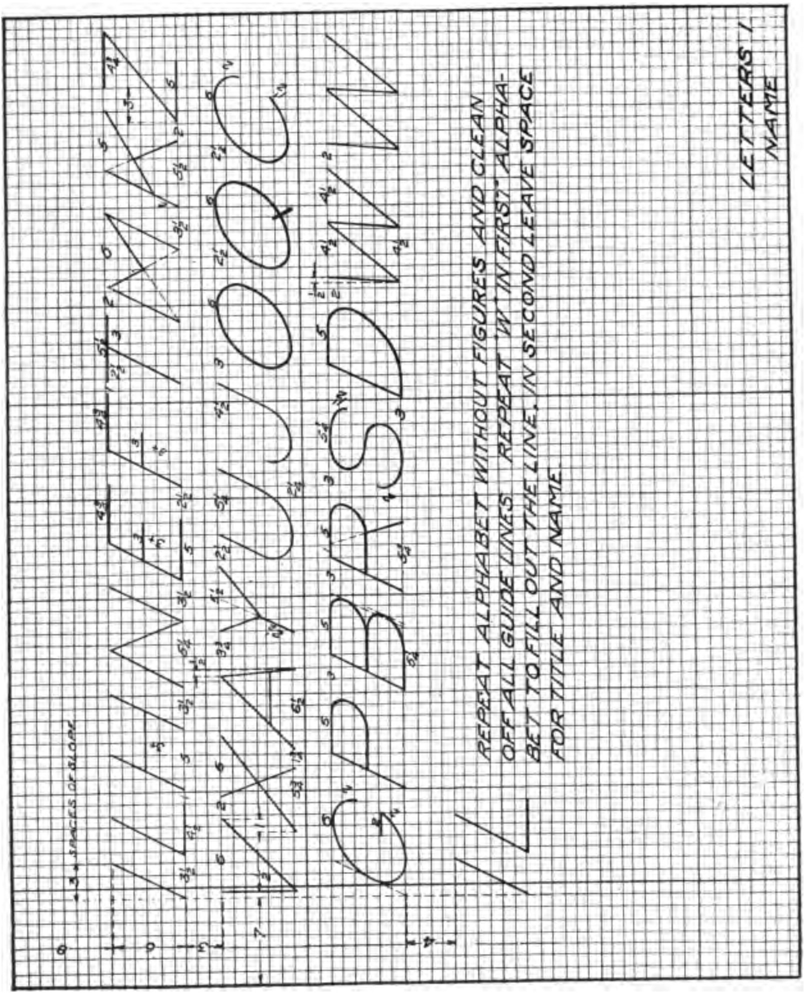


NOTE: THE STUDENT WILL LAY OUT AN 18"X24" SHEET SHOWING A FULL PIPING PLAN FROM THE SKELETON PLAN GIVEN. ASSUME CONVENIENT LENGTHS FOR THE PIPING AND CONSTRUCT ALL FITTINGS ISOMETRICALLY, SIMILAR TO THE ONES SHOWN. DRAWING TO BE FULLY DIMENSIONED.

FIG. 39

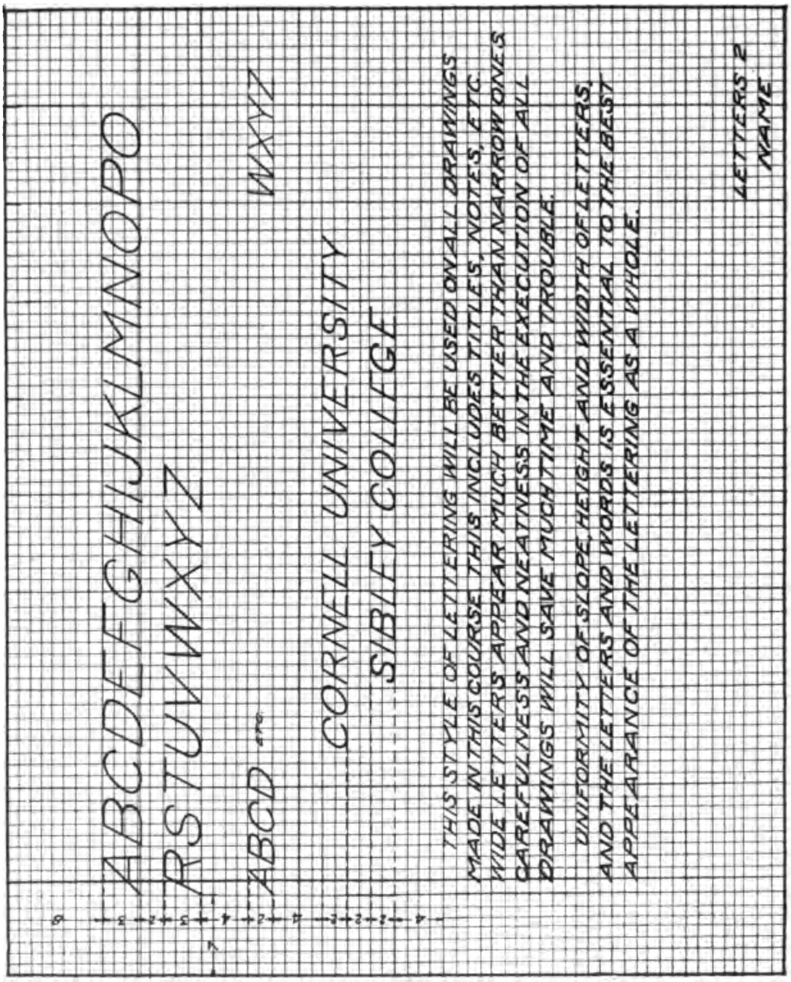
its sides projected as ellipses. The approximate ellipse may be constructed by the following method: Bisect the lines *a–b*, *c–d*, *a–c*, and *d–b*, and connect the points 1, 2, 3, and 4 to the corners *a* and *d*, as shown; these connecting lines intersecting at 5 and 6. Points 5 and 6 may be used as centers for the arcs of the end of the ellipse, and points *a* and *d* for the larger arcs as shown. The same construction is used for the other faces of the cube. Construct an ellipse after this fashion in the plane 1, 2, 3, Fig. 38, making the vertical distance = ⅝″ and the incline distance = ⅝″. A similar construction in the plane with the connecting lines as shown completes the isometric projection of the cylindrical portion. The construction of the hollow portion explains itself from the figure. Particular attention is called to the manner in which the dimension lines are placed on this kind of a drawing. The application of the principles of isometric drawing to the laying out of pipe-lines may be seen from Fig. 39, page 63. No explanation is needed in regard to the making of a drawing of this particular kind, since the figure itself contains all the information needed.

A number of examples to be drawn suggest themselves. The authors have used the shop exercises previously sketched and drawn by the student with good results. Simple examples should be selected first and then the more difficult ones.



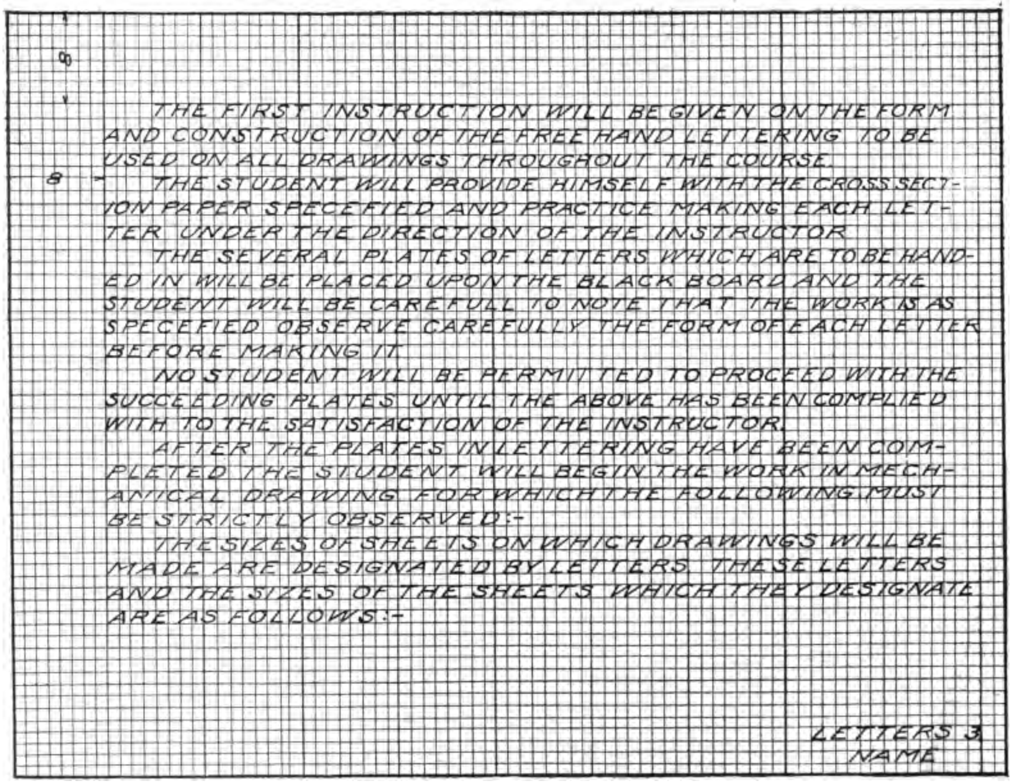
REPEAT ALPHABET WITHOUT FIGURES AND CLEAN OFF ALL GUIDE LINES. REPEAT "W" IN FIRST ALPHABET TO FILL OUT THE LINE. IN SECOND LEAVE SPACE FOR TITLE AND NAME.

LETTERS I
NAME



THIS STYLE OF LETTERING WILL BE USED ON ALL DRAWINGS MADE IN THIS COURSE. THIS INCLUDES TITLES, NOTES, ETC. WIDE LETTERS APPEAR MUCH BETTER THAN NARROW ONES. CAREFULNESS AND NEATNESS IN THE EXECUTION OF ALL DRAWINGS WILL SAVE MUCH TIME AND TROUBLE.

UNIFORMITY OF SLOPE, HEIGHT AND WIDTH OF LETTERS, AND THE LETTERS AND WORDS IS ESSENTIAL TO THE BEST APPEARANCE OF THE LETTERING AS A WHOLE.



THE FIRST INSTRUCTION WILL BE GIVEN ON THE FORM AND CONSTRUCTION OF THE FREE HAND LETTERING TO BE USED ON ALL DRAWINGS THROUGHOUT THE COURSE.

THE STUDENT WILL PROVIDE HIMSELF WITH THE CROSS SECTION PAPER SPECEFIED AND PRACTICE MAKING EACH LETTER UNDER THE DIRECTION OF THE INSTRUCTOR

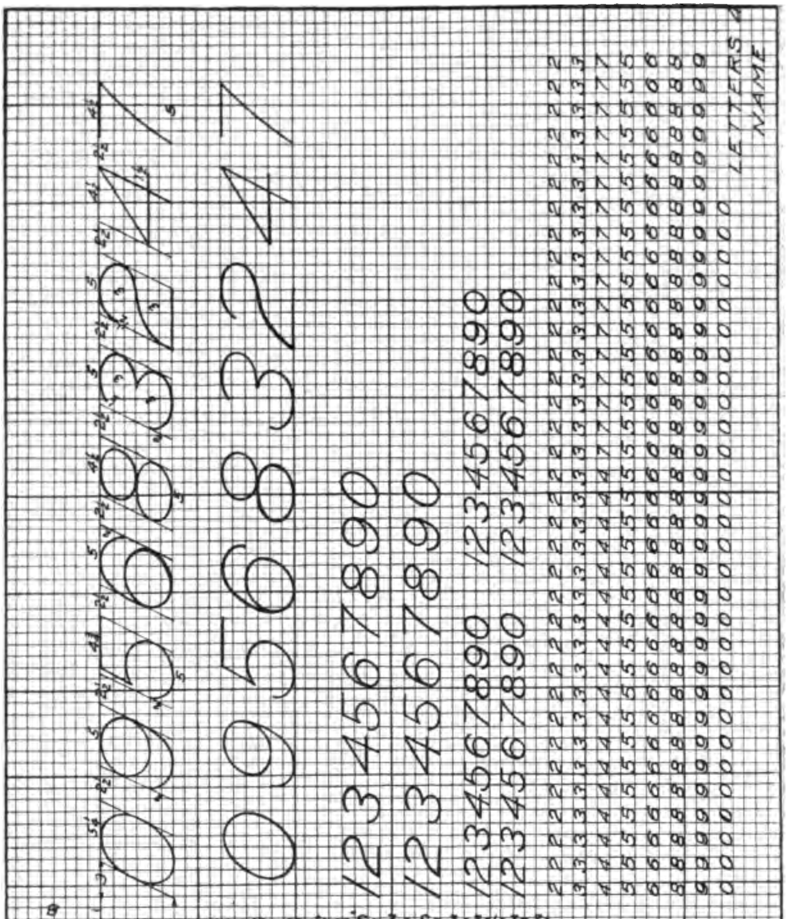
THE SEVERAL PLATES OF LETTERS WHICH ARE TO BE HANDED IN WILL BE PLACED UPON THE BLACK BOARD AND THE STUDENT WILL BE CAREFULL TO NOTE THAT THE WORK IS AS SPECEFIED OBSERVE CAREFULLY THE FORM OF EACH LETTER BEFORE MAKING IT

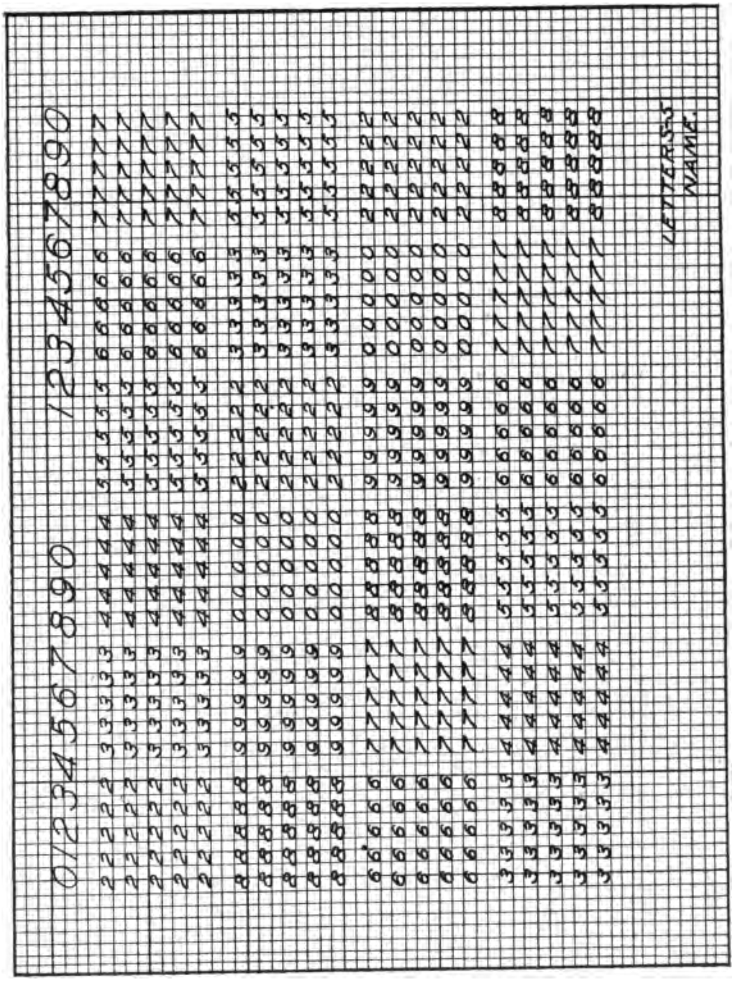
NO STUDENT WILL BE PERMITTED TO PROCEED WITH THE SUCCEEDING PLATES UNTIL THE ABOVE HAS BEEN COMPLIED WITH TO THE SATISFACTION OF THE INSTRUCTOR.

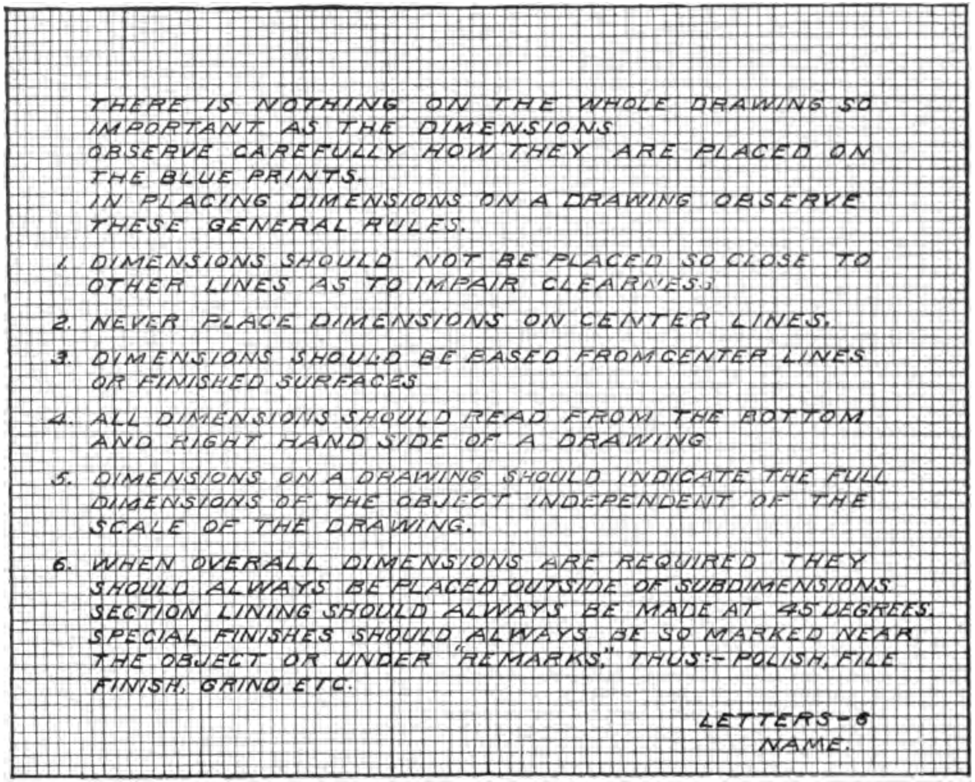
AFTER THE PLATES IN LETTERING HAVE BEEN COMPLETED THE STUDENT WILL BEGIN THE WORK IN MECHANICAL DRAWING FOR WHICH THE FOLLOWING MUST BE STRICTLY OBSERVED:-

THE SIZES OF SHEETS ON WHICH DRAWINGS WILL BE MADE ARE DESIGNATED BY LETTERS. THESE LETTERS AND THE SIZES OF THE SHEETS WHICH THEY DESIGNATE ARE AS FOLLOWS:-

LETTERS 3
NAME


0958 3247
0958 3247
1234567890
1234567890
1234567890 1234567890
1234567890 1234567890
LETTERS
NAME


01234567890
1234567890
LETTERS
NAME



THERE IS NOTHING ON THE WHOLE DRAWING SO IMPORTANT AS THE DIMENSIONS.
OBSERVE CAREFULLY HOW THEY ARE PLACED ON THE BLUE PRINTS.
IN PLACING DIMENSIONS ON A DRAWING OBSERVE THESE GENERAL RULES.

1. DIMENSIONS SHOULD NOT BE PLACED SO CLOSE TO OTHER LINES AS TO IMPAIR CLEARNESS.

2. NEVER PLACE DIMENSIONS ON CENTER LINES.

3. DIMENSIONS SHOULD BE BASED FROM CENTER LINES OR FINISHED SURFACES

4. ALL DIMENSIONS SHOULD READ FROM THE BOTTOM AND RIGHT HAND SIDE OF A DRAWING

5. DIMENSIONS ON A DRAWING SHOULD INDICATE THE FULL DIMENSIONS OF THE OBJECT INDEPENDENT OF THE SCALE OF THE DRAWING.

6. WHEN OVERALL DIMENSIONS ARE REQUIRED THEY SHOULD ALWAYS BE PLACED OUTSIDE OF SUBDIMENSIONS.
SECTION LINING SHOULD ALWAYS BE MADE AT 45 DEGREES.
SPECIAL FINISHES SHOULD ALWAYS BE SO MARKED NEAR THE OBJECT OR UNDER "REMARKS." THUS:- POLISH, FILE FINISH, GRIND, ETC.

LETTERS-6
NAME.

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